DEPARTMENT OF FAMILY & CONSUMER SCIENCES

NUTRITIONAL STATUS OF CHILDREN (6 to 13 YEARS OF AGE) IN TUBU AND SHOROBE *MOLAPO* AND *NON-MOLAPO* FARMING HOUSEHOLDS, NGAMILAND, BOTSWANA

BY

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DEDICATION

I dedicate this work to my lovely Grandma, Bantle Kebaswele, and all her children. You are an exceptional type. Thank you for instilling in us the value of supporting one another towards goal achievement. May God continue being the Main Shareholder in the family and in influencing you to show more love and support not only to your own family but to all who The Lord brings to your circle. I also dedicate this work to my wonderful and awesome husband, Mr Taona Mutumwa. Thank you for your spiritual fervency that you put to use to guide me in this work. Finally, I dedicate this work to all who have been told they couldn’t make it. The plans of God are different from those of people. Run your own race by The Grace of God and desist from running the race of others. Glory be to God.

PHILLIPIANS 4:13

I can do all things through Christ which strengthens me

ZECHARIAH 4: 6b

“Not by might, nor by power, but by My Spirit”, saith the Lord of Hosts

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ABSTRACT

NUTRITIONAL STATUS OF CHILDREN (6 to 13 YEARS) IN TUBU AND SHOROBE *MOLAPO* FARMING HOUSEHOLDS, NGAMILAND, BOTSWANA

By Tshepiso Galase Ramolefhe-Mutumwa

Committee Chair: Maria S. Nnyepi, Ph.D.

Background: The size of floods in the Okavango Delta (OD), Botswana varies annually and seasonally over long periods (decadal). This influences crop production, food security, health and nutritional status of dependent farming households and especially of vulnerable populations such as children. Unlike the under-fives, school age children (SAC) and especially those living in rural, farming and resource poor households have been neglected in health research and not much is known about their nutritional status.

Objective: To determine the nutritional status of children (6 to 13 years) in farming households of Tubu and Shorobe villages over the lean and plenty seasons.

Methods: Using a cross sectional study design, samples of 84 and 134 children (6 to 13 years) were assessed during the lean and plenty seasons for nutritional status indicators of growth (stunting, underweight, thinness and overweight and obesity), meal patterns, serum iron and zinc status, prevalence of soil transmitted helminthes (STH), relationship between STH and iron status, household food security status and factors influencing nutritional status.

Results: Double burden of malnutrition was evident in the study children. Prevalence of underweight, stunting, thinness and overweight/obesity during the lean season was 12.3%, 6%, 11.9% and 4.8% respectively, whereas in the plenty season they were 6.3%, 5.2%, 7.4% and 4.4% respectively. Regardless of season, age, and/or farming system, the bulk (>60%) of the children's diets were predominately starchy foods such as cereals (>91%), sugar/honey (>84%), miscellaneous foodstuffs (condiments, beverages such as tea and coffee) (>78%) and meat/poultry/offal (>61%).

Overall, no more than 27% of all children had representation of roots and tubers, vegetables, fruits, eggs, fish and seafood and pulses/legumes/nuts in their diets in the previous day. Unexpectedly, there was a higher prevalence of anemia at 34% (n=18/53) during the plenty season compared to 17.4% (n=4/23) in the lean season. One girl child, aged 6 years and from a *molapo* farming household was zinc deficient, with levels below 9.9umol/L. There was a low (0.75%) prevalence of STH but increased intestinal polyparasitism (lean: 7.1%; plenty: 11.2%) associated with poor food handling and preparation- as well as hygiene and sanitation practices. Food insecurity was common amongst households in both lean (95.7%) and plenty (88.7%) seasons. Over 67% of households in both seasons experienced worry over food supply for the previous month, and consumed food of low quality and quantity. Significant differences were only observed when comparing mean WAZ by season (lean: 0.8±0.9 and plenty: 0.5±1.0, t (133) = -2.144, $p<0.05$) and mean BAZ by age (6 to 9 years: 0.8±0.8 and 10 to 13 years: 1.0±0.9, t (208) = 2.341, $p<0.05$). Child age significantly influenced thinness. Household income, the plenty season and Tubu village were negatively associated with meal patterns (dietary diversity). On the contrary, farming system was positively associated with dietary diversity. Household income negatively influenced household food security.

Conclusion: Although the study SAC seemed to have poor nutritional status, generally, they fared better than the under-fives in the nation. Nonetheless, significant health concerns that must be quickly addressed in the studied communities included undernutrition (underweight and thinness), limited dietary diversity, poor food handling and preparation practices and poor hygiene and sanitation practices, and pervasive household food insecurity. Nutritional status of SAC deteriorated more during the plenty season. Loss of crops to floods, which is an indicator of climate change majorly affected SAC nutritional status, household food security and dietary diversity. *Molapo* farming is a promising system towards improving dietary diversity.

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ABBREVIATIONS USED IN THE STUDY

1. A. lumbricoides: Ascaris lumbricoides
2. BAZ: Body Mass Index for Age Z scores
3. BEP: Botswana Ecohealth Project
4. BIDPA: Botswana Institute of Development Policy Analysis
5. CBNRM: Community Based Natural Resource Management
6. CDC: Centre of Disease Control
7. CSO: Central Statistics Office Botswana
8. DD: Dietary diversity
9. EDTA: Ethylene di-amine tetra acetic acid
10. EPG: Egg per gram
11. FC: Farmer’s Committee
12. FSIN: Food Security Information Network
13. g: Grams
14. Hb: hemoglobin
15. HDDS: Household Dietary Diversity Score
16. HAZ: Height for Age Z scores
17. HH: Household
18. HFIAS: Household Food Insecurity Access Scale
19. IAEA: International Energy Atomic Agency
20. IASO: International Association for the Study of Obesity
21. ID: Iron deficiency
22. IDA: Iron deficiency anemia
23. IOTF: International Obesity Task Force
24. IZiNCG: International Zinc Nutrition Consultative Group

25. Kcal: Kilocalories
26. LAC: Latin America and the Caribbean
27. MCV: Mean Corpuscular Volume
28. MCHC: Mean Corpuscular Hemoglobin Concentration
29. MDGs: Millennium Development Goals
30. MoE: Ministry of Basic Education
31. MoHW: Ministry of Health and Wellness
32. MoLG: Ministry of Local Government and Rural Development
33. MICS: Multiple Indicator Cluster Survey
34. n: sample size
35. N: Population size
36. N/A: Not applicable
37. NFTRC: National Food Technology Research Centre
38. N.d: Not dated
39. NCHS: National Centre for Health Statistics
40. OD: Okavango Delta
41. OW/OB: Overweight/obesity
42. PRA: Participatory Rural Appraisal
43. PEM: Protein energy malnutrition
44. RPM: Revolutions per minute
45. SAC: School age children
46. SD: Standard Deviation
47. SDGs: Sustainable Development Goals
48. SE: Standard Error
49. SFP: School Feeding Program

50. SHP: School Health Policy
51. SSA: Sub Saharan Africa
52. STfR: Soluble Transferrin Receptors
53. STH: Soil transmitted helminthes
54. SUN: Scaling up Nutrition
55. t: t statistic/ value
56. TIBC: Total Iron Binding Capacity
57. T. trichiura: Trichuris trichiura
58. UNICEF: United Nations Children's Fund
59. UN: United Nations
60. USA: United States of America
61. WASH: Water Sanitation and Hygiene
62. WFP: World Food Programme
63. USAID: United States Agency for International Development
64. VDC: Village Development Committee
65. WHO: World Health Organization
66. WAZ: Weight for Age Z scores
67. Z: Z value
68. ZD: Zinc deficiency

CHAPTER 1 INTRODUCTION

Routine nutritional assessment is important in providing information on the growth and development of children. Nonetheless, literature shows that certain population groups of children have limited assessment data. One such population group is that of school age children (SAC) between 6 and 14 years (Caleyachetty et al, 2018; Pérez-Ríos et al, 2018; Modjadji & Madiba, 2019a, 2019b). Children in the school age group are vulnerable to compromised nutritional status because of rapid development. The SAC undergo rapid physical, behavioural and psychological changes that influence nutritional wellbeing and overall health (Esaulenko et al, 2017).

Generally, children globally are grappling with malnutrition (Gebre et al, 2019). Globally, an estimated 156 million children are stunted while 50 million are wasted and 42 million are overweight and obese (WHO, 2018a). The scarce research on SAC seems to point to the same pattern of vulnerability. Malnutrition estimates around the world in this age group range between 12% and 50.2% in stunting and between 3.4% and 53.3% in underweight (Wahed et al, 2017; Karajibani et al, 2019; El-Fatah and Abu-Elenin, 2019). Moreover, there seems to be extra vulnerability for children living in poverty stricken, frequently stressed and lowly resourced rural communities such as those in farming areas (FAO, 2019).

Similar to the global picture, Botswana is persistently depicting high malnutrition prevalence especially in the under-fives (Central Statistics Office, 2009; Ramolefhe et al, 2011; Codjia and Nnyepi, 2011). In the under-fives, 31.4% are reported to be stunted, 11.2% overweight, 7.2% are wasted, 11.9% are underweight, 43% anemic and 26% vitamin A deficient (World Bank, 2011; Stevens et al, 2013; Scaling up Nutrition, 2018). In older children above 15 years, 48% were estimated to be overweight and/or obese (Central Statistics Office, 2009).

Contrarily, there are no recent studies of malnutrition on the SAC between the ages of 6 and 13 years in Botswana. However, if malnutrition is increasing in the other age groups in Botswana, then SAC are probably affected too. Furthermore, the limited research available in this age group in the country is on children living in the peri-urban to urban areas and less to none on those residing in rural and farming areas (Abrams et al, 2003). Rural and farming communities usually have limited resources and tend to be affected more by natural shocks such as insufficient rains, droughts, floods and crop damage from both water and wildlife (Botswana Ecohealth Project, 2010). Consequently, these shocks expose those living in rural and farming communities to the vulnerability of food shortages, disease outbreaks and all forms of malnutrition (Rodriguez-Lianess et al, 2011).

Efforts towards malnutrition amelioration in Botswana

Like all governments, Botswana also took part in all the proposed initiatives towards the betterment of her people's wellbeing. The country has seen the adoption of a universal health care system, child welfare care for the under-fives at clinics, school feeding programs (SFP) and school health policy (SHP). Of interest to the study population are the SFP and the SHP.

Although these were formally founded with an intention to promote SAC wellbeing, shortfalls in the programs have been identified that could possibly hinder full achievement of child welfare in SAC (Shaibu and Phaladze, 2010; Mozola, 2015). The following are described briefly:

School Health Policy

The SHP was founded in 1999 with the objectives of conducting general health assessments of children in primary school on the first and last years of school, offering health education to both pupils and teachers and conducting a thorough assessment of the school environment (BIDPA, 2013). Details of the assessments are to be recorded in the pupils transfer card (Botswana National School Health Policy and Procedure Manual, 1999). Like the SFP, gaps in the delivery of school health services can compromise the effectiveness of the program. Some of these shortfalls previously cited include lack of private spaces where thorough assessments could be carried out and shortage of trained and specialized staff such as dentists, environmentalists and doctors (Shaibu and Phaladze, 2010). It has even been reported that school health service programs are still non-existent in some districts (Shaibu and Phaladze, 2010). This may be further supported by lack of trained healthcare workers worse off in primary healthcare and rural areas (Nkomazana et al, 2015). What more of school health service programs? Where existent, there seems to be poor implementation (Mozola, 2015).

School Feeding program

This program which started when the country gained independence was initially funded by the World Food Programme (WFP), but began to be fully funded by Botswana in 1998 (Mosie, 2004; Government of Botswana et al., 2013). The program objective is to increase enrolment, reduce hunger and increase children's concentration during school hours (Botswana Institute of Development Policy Analysis (BIDPA), 2013). Similarly, the school feeding program in Botswana is well paced to better the nutritional status of SAC.

Despite efforts of feeding children at school through the SFP, some gaps have been identified. These include such issues as small portion sizes, lack of diversity of meals (except during harvest time when local farmers can supply schools with fresh produce through a tendering system), unreliable food supplies to schools, lack of SFP policy to guide program implementation and lack of one direct coordinating body; all of which may undermine the potential of the program in minimising the vulnerability caused by malnutrition, poverty and food insecurity especially in impoverished rural and framing areas (BIDPA, 2013; Drake et al., 2016).

Lack of nutritional assessment data in the SAC imply that there is a gap in the knowledge of the nutritional status and/or wellbeing of this age group. This goes against the objectives of the SFP, SHP and the Vision 2036 pillar of Human and social development, which seeks to have "a safe and enabling environment for children to grow to reach full potential through strong family support, safe and secure environment, quality education and health" (Government of Botswana, 2016). With this gap, SAC's wellbeing seems compromised.

Vulnerability of living in the Ngamiland District

It may be that SAC in the Ngamiland are likely more vulnerable to malnutrition because of compromised living environment and conditions. The Ngamiland District, where the study was conducted is one of the poorest districts in Botswana, with 33.4% and 21.6% of households in West and East Ngamiland respectively living below the poverty datum line. This is very high in comparison to the nation's average of 19.3% (Statistics Botswana, 2018). Many households in the Ngamiland District practice farming (crops and livestock keeping) as the main source of livelihoods. However, farmers face challenges from the unfavourable climate and wildlife. There have been reports of farmers loosing crops and/or ending with lower than expected yields due to wild animals destroying and/or eating the crops (Bosekeng et al, 2017). Furthermore, the semi-arid climate of Botswana characterized by erratic rainfalls, high temperatures and droughts seem to provide unfavourable conditions to crop yield and pastures.

Problem Statement

Despite limited information on SAC worldwide, existing evidence show that SAC struggle with malnutrition (Best et al, 2010). In the year 2000, it was estimated that over 200 million SAC were stunted. It was also projected that this year of 2020, up to 1 billion of stunted SAC will be impaired physically and mentally (Dangour & Uauy, 2006). Similarly, 155 million SAC are still estimated to be overweight and obese worldwide; a challenge that is believed will reduce life expectancy to lower than that of parents (International Association for the Study of Obesity, 2010).

Similarly, in Botswana, malnutrition is a pervasive problem. It is estimated that amongst the under-fives, 31.4% are stunted, 11.2% overweight, 43% anemic and 26% are vitamin A deficient (Stevens et al, 2013; SUN, 2018). Given the prevalence of high malnutrition in under-fives, it is conceivable that SAC (6 to 13 years) are likely to be affected too. However, there is a serious gap in understanding the nutritional status of SAC in the country. This is more likely true for low resourced rural and farming communities such as those in the Ngamiland District. That Ngamiland is commonly plagued by natural shocks, makes the problem bigger.

Due to the unpredictability of rainfall in the country, most of the local poor and the vulnerable farming communities in the Ngamiland District reside along the fringes of the Okavango Delta. They are lured there by the soil fertility and moisture from receding floods as the water enters the Okavango Delta from the Angolan highlands.

The resultant high water table is then used to support a locally practiced farming system known as *molapo* (plural: *melapo*) farming (flood recession farming) (Vanderpost, 2009; Motsholapheko et al, 2012; Motsumi et al, 2012).

Generally, due to the relatively fertile, heavier and moist soils in *molapo* farms, the system has been shown to be more productive compared to rain-fed farming (Bendsen, 2002; Murray, 2005). However, despite these attractive characteristics favouring cultivation of *melapo* farms, output is largely dependent on flood variability. The size of floods in the Okavango Delta (OD) in the Ngamiland district of Botswana varies annually and seasonally over long periods (decadal) thereby influencing crop production and yield.

Bosekeng et al, (2017) showed that resultant level of moisture from floods and/or rain and/or the combination of the two may influence crop yield. In the study, it was shown that too high and/or too low moisture affected plant growth processes. Excess moisture led to poor plant stand and delayed flowering whereas lower moisture content led to delayed germination (Bosekeng et al, 2017).

Variability in flood distribution may exert strong influence on the livelihood of the dependent communities through its impact on crop damage (Kolawole et al, 2016). The damage of crops by differing moisture levels may end up compromising food availability which has an indirect impact on many other aspects such as growth status, meal patterns, micronutrient status and food security status of dependent farming households (Kgathi et al, 2005; Molefe et al, 2014).

Excessive flooding may cause infections and/or provide optimum environment for such disease causing agents as soil transmitted helminthes (STHs) and mosquitos amongst others leading to a down spiral in the community health especially of children (McCann et al, 2011).

Moreover, SAC working with their families in the *melapo* farms may also be in contact with infected soils, which puts them at risk for infection with STH. Long term infection with STH may lead to chronic blood loss and eventually iron deficiency (ID) and/or the severe form, iron deficiency anemia (IDA) (Alelign et al, 2015; Cojulun et al, 2015).

The nutritional status of the SAC in the melapo farms in the Ngamiland seem to be unpredictable and highly dependent on flood variability patterns. Understanding the nutritional status of this group may be just what is needed to offer appropriate, timely and relevant help.

Justification of the study

This study is important in understanding the nutritional status of the SAC residing in Tubu and Shorobe *molapo* farming communities in the context of flood variability and subsequent seasons. As much as the floods are useful for farming purposes, it is unknown how the nutritional status of the children is affected. It is critical to understand SAC's nutritional status as they are in their active growth period. Any failure in growth and development will likely affect future development milestones such as school attendance and educational performance (Siddiqi et al, 2011; Caleyachetty et al, 2018).

Left unattended, malnutrition in SAC has potential to undermine productivity levels and contribution to the overall economies of communities and country at large during adult stage (WHO, 2018a). Consequently, this may perpetuate a cycle of poverty, malnutrition and dependency on government aid. Moreover, without data on nutritional status of SAC, the Botswana vision 2036 and the SDG of improved health and well-being in children are defeated. Finally, appreciation of the SAC nutritional status in the context of the seasons aforementioned would assist in the development of appropriate and relevant strategies that can better improve wellbeing.

Study Significance

The findings of the study will be beneficial in several ways. Firstly, they will provide baseline information on the nutritional status of SAC in the rural and farming areas of Ngamiland district. Secondly, this information can also be used by policy makers and stakeholder Ministries such as Ministry of Basic Education, Ministry of Health and Wellness and Ministry of Local Government and Rural Development to refocus existing programs (SFP) and policies (SHP) that are critical to the improvement of SAC health.

Thirdly, the findings will also shed a light on the overall wellbeing of the rural and farming communities in the Ngamiland district practicing *molapo* farming. This is influenced by the idea that children are quick to respond to any changes in wellbeing, hence they can show the overall quality of life of the community they live in (Ilo et al, 2015).

Fourthly, understanding of how the nutritional status of this age group varies in the context of seasons will help to best tailor strategies needed to improve child wellbeing. Finally, the findings can be informative to *molapo* farming health educators on how best to educate the community to take care of children in the different seasons to achieve optimum wellbeing.

Purpose

This study therefore intended to assess and describe the nutritional status of SAC (6 to 13 years) in Tubu and Shorobe *molapo* and *non-molapo* farming households during the lean and plenty seasons. The assessment will include growth status (stunting, underweight, thinness, overweight and obesity (OW/OB)), meal patterns, micronutrient malnutrition, prevalence of soil transmitted helminthes (STH), relationship assessment between STH and iron status and household food security status in SAC residing in the impoverished, rural farming areas of Ngamiland District.

Study Objectives and Questions

Corresponding objectives and research questions guiding the study are listed below:

Objective 1: To assess the prevalence of stunting, underweight, thinness, overweight and obesity in children (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons.

Research Question: What are the prevalence of stunting, underweight, thinness, overweight and obesity in children (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons?

Objective 2: To describe the meal patterns of children (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons.

Research Question: What are the meal patterns of children (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons?

Objective 3: To determine serum iron and zinc status of children (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons.

Research Question: What is the status of serum iron and zinc of children (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons?

Objective 4: To determine the prevalence of soil transmitted helminthes infestations in (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons.

Research Question: What is the prevalence of soil transmitted helminthes infestations in children (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons?

Objective 5: To establish the relationship between soil transmitted helminthes and iron status in children (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons.

Research Question: What is the relationship between soil transmitted helminthes and iron status in children (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons?

Objective 6: To assess the level of food security in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons.

Research Question: What is the level of food security in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons?

Objective 7: To identify factors influencing nutritional status and determine relationship to nutritional status indicators.

Research Question: What are the factors that influence nutritional status in children (6 to 13 years) in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages during the lean and plenty seasons?

Conceptual framework

The child nutritional status framework by Smith & Haddad, 2015 (Figure 1) was used to guide this study. It is worth noting that it was adapted from the UNICEF causes of malnutrition framework (UNICEF, 1990).

The framework expounds on the first two levels of the causes of malnutrition which are the immediate and underlying. The scope of this study is delimited to the immediate and underlying causes of malnutrition as shown in the framework (Figure 1).

Immediate Factors

These factors are known to directly affect the child's nutritional status. These include dietary intake and health status. The idea is that when the child does not consume food of acceptable quality and quantities, then he /she may not be able to meet lifecycle nutrient needs and thus fail to attain healthy growth (Smith & Haddad, 2015). Such a poorly nourished child is prone to infections and illnesses. Illnesses may also increase nutrient needs and depress the child's appetite; both of which will promote malnutrition. In this study variables of interest that fall under the dietary intake are the child's dietary diversity (measured using number of food groups represented in the diet) and the dietary diversity score. This decision was informed by works showing that consumption of diverse diets is likely to provide adequate nutrients (Swindale & Bilinsky, 2006; Kuczmarski et al, 2019).

Variables of interest for child health status include occurrence of sickness in the past month (30 days), infestation with STH and the intensity of the infestation and micronutrient status (serum iron and zinc). The decision is informed by evidence that if the child's body is compromised by sickness, they may be unable to absorb nutrients properly leading to poor nutritional status (Michaelsen et al, 2020).

Underlying Factors

In the second layer of the determinants of child nutrition, the children, caregiver and household characteristics have a role in the wellbeing of the child. The status of the aforementioned may directly influence the immediate factors particularly the dietary intake and health status of the child.

Under this level, variables of interest that fall under household food security are household food insecurity access categories (food secure vs food insecure), and household food insecurity access scores (HFIAS). The score is a continuous measure signifying the degree of food insecurity. These variables are outlined by Coates et al, 2007, see appendix 12 and 13.

Variables of interest under care for mother and child include caregiver characteristics such as age, education, marital status, occupation and caregiver relation to child which can influence child nutritional status. Selection of these variables was informed by evidence in the literature suggesting that when a caregiver is experienced with child care, has knowledge and the right support whether income or relationship-wise, they are able to make decisions that can favour the health of the child (Emamian et al, 2013; Ickes et al, 2015; Assefa et al, 2015).

Lastly, under health environment and services, variables of interest include action taken when the child is sick, household size, safe water supply and adequacy of sanitation. These are important because access to them helps curb the spread of diseases in the environment and to the child thus preventing malnutrition (UNICEF, 2013a).

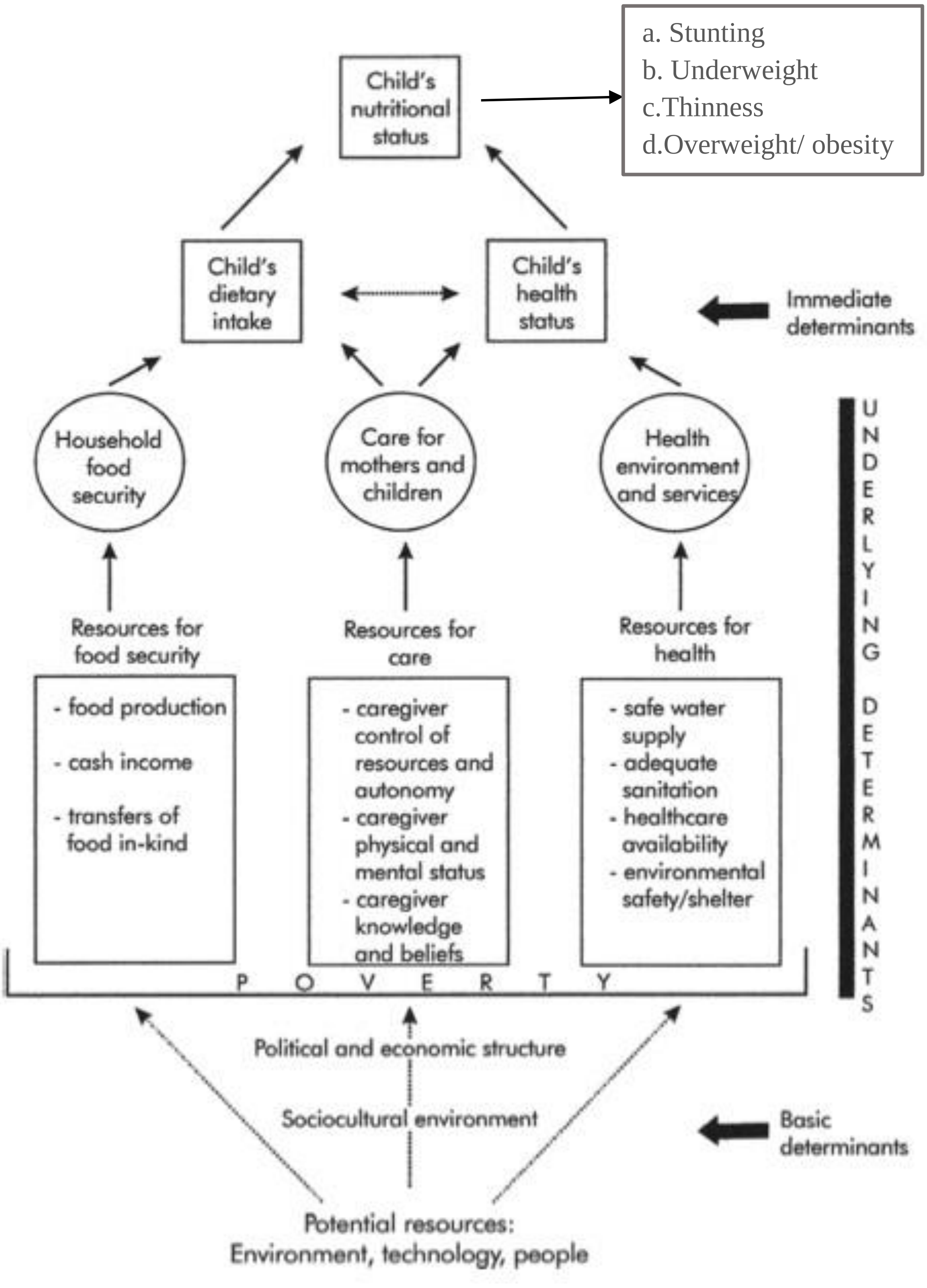

Figure 1 Conceptual framework addressing child's nutritional status.

Source: Adapted from Smith and Haddad (2015) also adapted from UNICEF Framework of causes of malnutrition (UNICEF, 1990)

CHAPTER 2 LITERATURE REVIEW

The first 1000 days of life constituting the period between the mother's pregnancy and her child's second birthday are crucial towards foundations for optimum health and development across lifespan (Cusick & Georgieff, N.d). This foundation continues to be built onto the later stages between ages of 3 to 5 years as the brain continues to develop. Equally important is the school age period consisting of children between the ages of 6 and 13 years, which holds high importance towards children's cognitive development, learning capabilities and grasping of abstract concepts (Lefa, 2014). However, a malnourished child may not be able to meet these milestones and may be rendered incapable to compare at par in many levels including mental and intellectual capacities with age mates. It is thus critical that nutritional assessment of children be performed at an early age to ensure that where necessary interventions are availed to prevent children's deterioration in growth, development and health.

Though limited, data available suggest that the SAC are suffering from both undernutrition and overnutrition (Jafari et al, 2014; Kroker-Lobos et al, 2014; Mohamed and Hussein, 2015; Lobstein et al, 2015; Wolde et al, 2015). Malnutrition in any form is a risk factor for diseases and premature death (Global Nutrition Report, 2018). In 2011, it was indicated that SAC were the first generation to have a lower life expectancy than their parents due to increased overweight and obesity which was responsible for introducing metabolic syndromes (Martins et al, 2011).

SAC comprise approximately 24% of the populations in developing countries and 15% in the industrialized ones (Leslie and Jamison, 1990; Chesire et al, 2008). Further, the world is currently a home to 1.8 billion adolescents that make the largest generation in human history (Christian and Smith, 2018). It is also estimated that in Sub Saharan Africa, more than half of the population are adolescents (Christian and Smith, 2018). Such proportions in the world population validate need for attention.

This section generally makes a case for studies that focus on the nutritional status of primary school age group of 6 to 13 years around the globe. Therefore, the section is divided into two parts. The first part makes a case from the literature on the need to particularly focus on 1) SAC 2) SAC living in rural farming areas and 3) nutritional status aspects according to seasonality.

The second part focuses on all aspects of nutritional status as covered in the study (anthropometric, meal patterns, micronutrient status, STH, relationship between STH and iron status, household food security) and factors influencing nutritional status and as guided by the child nutritional status framework (UNICEF, 1990; Smith and Haddaad, 2015). However, the literature review will be organized according to the different levels in the framework showcased as three sections.

The first section was on the manifestation of poor nutritional status covering objective 1 on anthropometry. It was followed by factors that influenced stunting, underweight and thinness. The second section discussed the immediate determinants which cover 1) child dietary intake covered by objective 2 on meal patterns 2) child health status covered by objectives 3 on serum iron and zinc status 3) STH covered by objective 4 and 4) relationship of iron status and STH which is objective 5. Factors that influenced each of these aspects was presented.

The third section covered 1) objective 6 on household food insecurity status as well as the role of 2) caregiver characteristics and 3) health environment and services on the nutritional status of the child covered by objective 7. Similarly, factors that influenced these aspects were also presented.

Importance of focusing on school age children

A couple of extensive reviews have been conducted documenting that SAC are vulnerable to malnutrition. One such review was conducted in 76 countries between 2002 and 2009 (Best et al, 2010). In this review of 369 studies, it was concluded that SAC from the different world regions (Africa, Latin America, South-east Asia, Western Pacific and the Eastern Mediterranean) suffered nutrient deficiencies and a double burden of malnutrition (undernutrition and overnutrition), yet they were commonly neglected in public health research. The other review quantified the magnitude of the double burden of malnutrition in the SAC in 57 low and middle income countries (Caleyachetty et al, 2018). This review reached a conclusion that the double burden of malnutrition was common in this age group. Although it may seem that there is plenty of research on the age group by looking at the number of papers and/or countries covered in the reviews, some regions seemed to have insufficient evidence and/or have evidence from weakly designed studies (Best et al, 2010; Caleyachetty et al, 2018). In particular, Africa had limited studies that explored nutritional status of SAC. Hence more comprehensive research is needed in this age group in the African settings.

Generally, children in the age range of 6 to 13 years are in primary schools. Many governments, Botswana included have school feeding programs which are developed to decrease hunger, keep children in school and enhance health through increasing food intake (Florencio, 2001; Mosie, 2004; BIDPA, 2013).

However, only a portion and not all of the nutritional requirements are met at school. In Botswana, primary school children usually spend half of day at school, hence they are provided with a meal that provides at least 30% of daily nutrient requirements for energy, protein and fat (BIDPA, 2013).

It is important therefore that the rest of the requirement be met at home. However, due to high poverty levels and food insecurity especially in rural (poverty rate: 24.2%; food insecurity: 50.2%) than urban areas (poverty rate: 13.4%; food insecurity: 37.5%), most children may be dependent on the sole meal provided at school for daily nutrition requirements (Statistics Botswana, 2018). It is therefore essential that studies such as the current one are routinely carried out to track the nutritional status of the children.

Equally to other countries, there is scarce evidence-based nutrition and health information on SAC (aged about 6 to 13 years) in Botswana. Most of the studies conducted in the country are on children under the age of 5 years (Mahgoub et al, 2006; Nnyepi, 2007; Ngwenya and Nnyepi, 2011; Ramolefhe et al, 2011) and adolescents over the age of 13 years (Maruapula et al, 2011; Wrotniak et al, 2012; Shaibu et al, 2012, Malete et al, 2013). However, close assessment of the school age group is important to assure optimal development, health and growth. Another major benefit of focusing on this age group is that if malnutrition is found to be a problem, then there is hope that with intervention, affected children can experience catch-up growth (Crookston et al, 2010; Frye, 2013; Prentice et al, 2013).

Importance of focusing on children in rural farming areas

Children in the rural areas face more challenges than those in urban areas mainly due to the economic status of the households (Schreuder, 2010; Bertolini, 2019). Rural children usually live in households ridden with poverty characterized by low income, which in turn contributes to low purchasing power and low dietary diversity (Tidemann-Anderson, 2011, Bertolini, 2019). Poor harvest caused by natural shocks such as floods and droughts are common (Irohibe and Agwu, 2014). Food insecurity and limited assets are also common (FAO, 2019). The disadvantageous situations experienced by rural households and children can predispose them to malnutrition, poor academic performance, low socially enriching activities and more adverse conditions affecting overall cognitive functioning (Lawal and Olukemi, 2010; Schreuder, 2010; Bertolini, 2019). All these can undermine children's developmental potential (Tadesse and Alemu, 2015) and make it difficult for them to break out of the circle of rural poverty (Schreuder, 2010). Furthermore, rural areas are usually isolated geographically from resourceful areas such as towns and cities. The evidence provided continues to paint a grim picture of the effect of poverty on the wellbeing of rural SAC.

A study on malaria and soil transmitted helminthes in primary school children residing in Mfou health district in Cameroon showed that a rural child had significantly increased chances of being underweight compared to his or her urban counterparts (Tchinda et al, 2012). Rural schoolchildren had more than 2-fold increased chances of being stunted compared to urban children. Similar results have been shown in Ethiopia (Ghate, 2014).

In a study just across the border in South Africa, it was found that undernutrition persisted in rural children despite efforts to address food insecurity through child support grants (Kimani-Murange et al, 2010). Because of limited resources in households, aid offered could not meet the nutrient needs of children.

In Botswana, there is not much known about this age group, more so, in the rural and farming areas. Hence, this study seeks to bridge this gap by assessing the SAC (6 to 13 years) in two rural and farming areas of Tubu and Shorobe villages.

Seasonality and nutritional status of school age children

The concept of seasonality cannot be ignored when discussing nutritional status of any population. Seasonality defines parts of the year marked by distinct changes in climatic conditions (humidity, wind, temperature, precipitation etc.), day lengths and ecological events such as floods and droughts (Osei et al, 2010). These changes may be influential in the outcome of many aspects that influence people's livelihood and nutritional status such as agricultural output (in terms of livestock keeping, crop growth and infections).

Seasonality may be defined using climatic seasons (summer, autumn, winter and spring) and agricultural seasons (pre-harvest usually corresponding to rainy/wet periods and leanness in the availability of food) and post-harvest (usually corresponding to dry seasons and plenty of food) (Osei et al, 2010; Egata et al, 2013; Chikhungu and Madise, 2014; Kinyoki, 2017).

Seasonality and growth status

Despite expectation that seasonality should always play a role in the nutritional status of people, there is nonetheless inconclusive evidence to this effect. Some literature attest to seasonality affecting nutritional status whereas others have not (Egata et al, 2013; Chikhungu and Madise, 2014). For instance, Egata et al, (2013) despite discovering seasonal mean weight difference between dry and wet seasons of 1.1kg±3.0 SD in Ethiopian rural children, failed to establish a significant association between season and acute child undernutrition. On the contrary, a significant association between season and child undernutrition was established for children in Malawi (Chikhungu and Madise, 2014). This study showed that during harvest/plenty season more children were significantly stunted and underweight compared to lean cropping season. However, these observations as unexpected as they were, were influenced by a seasonal pattern of child morbidity rather than availability of food.

Another study also showed a clear seasonal variation in Somalian children where a rise (11.2%) and a reduction (7.4%) of thinness was observed during the lean and plenty seasons respectively (Kinyoki, 2017). It can be deduced that differences observed in seasonal studies may be accounted to additional factors such as illness outbreaks, compromised care for children during harvesting period, availability of health services, and household socio economic status and not seasonality alone.

Seasonality and dietary intake

Scientific evidence show that diets are also influenced by seasonality, be it availability, the quality, quantity and/ or the pricing of food (Hirvonen et al, 2015; Herrador et al, 2015). In assessing how the quantity and quality of diets vary across agricultural seasons in rural and urban Ethiopia, Hirvonen et al, (2015) showed that indeed seasonality affected dietary quality, quantity, pricing and general intake.

It was shown that overall dietary diversity had a tendency to have a sharp drop during the lean season (10 288 kJ (2459) kcal in the plenty versus 9703 kJ (2319) kcal in the lean season, P<0·001).Dietary diversity followed a similar pattern with decrease during the lean season as well in the rural households (HDDS in the plenty season (6.73) versus in the lean season (5.98; P<0·001). The study also reported a rise in prices during the lean seasons as the harvest was declining.

In agreement with the Hirvonen study, Herrador et al, (2015) who studied determinants for low dietary diversity and lack of consumption of animal source foods amongst SAC in rural Ethiopia showed that seasonality influences diets and that there is better dietary diversity in urban children than rural ones. The study further indicated that dietary diversity was better in the plenty than the lean season. The latter proved true elsewhere (Odour et al, 2019).

Seasonality and micronutrient status

It is suggested that seasonal influence may have a role to play in influencing the micronutrient status. However, changes are not definite with a particular season. Gibson et al, (2011) observed the influence of seasonal variations in the zinc status of the urban and semi-urban children in New Zealand. In all children from the three ethnic groups, namely, Pacific, Nzeo and Maori, zinc deficiency plummeted during the plenty season than in the winter season (Gibson et al, 2011).

Roba et al, (2015) also reported the influence of seasons on anemia amongst lactating mothers in rural Ethiopia. It was shown that anemia was highest in the pre-harvest and/or lean season (40.9%) than post-harvest and/or plenty season (21.8%). Pre-harvest season corresponds with the lean season, which could point to the limited dietary intake.

Seasonality and haematological parameters

Seasonal variations may also influence hematologic parameters. Okebe et al, (2016) who focused on determining if seasonality had an effect on malaria confirmed that seasonality did have an effect on parameters such as lymphocytes, monocytes, platelets and hemoglobin. All these parameters point to the possibility of inflammation and/or stages of deficiencies in the body and tended to increase during the wet season and/or lean season.

The wet season provides a suitable environment for malaria causing agents such as the anopheles mosquitos which hide in puddles of water or mushes. Higher malaria parasite density may speed up the rate at which red blood cells are broken down thus resulting in severe anemia especially if the children are not able to produce new red cells at an equally accelerated rate (Opi et al, 2018). Although Okebe et al, study (2016) focused on malaria, it is relevant in that it shows that indeed seasonality can influence certain parameters which the current study observes such as hemoglobin.

Seasonality and STH

Like all other factors, it seems infestation with soil transmitted helminthes is also influenced by seasonality. It has been suggested in the literature that high incidence of STH infestation may be during the rainy and/or wet season (lean) whereas the opposite is during the hot dry (plenty) season (Avhad et al, 2012). Other studies found contradictory result with the highest prevalence of intestinal worms including STH infestations around autumn at 80.5% than in spring which had a prevalence of 43.9%. The difference in the findings could be due to the scope of the research as Avhad et al, (2012) focused only on STH whereas Kumar et al, (2014) generalized to include all intestinal worms; some of which may have different requirements for survival of ova and larvae.

Seasonality and household food security

Literature continues to show seasonal variations in rural household food security (Patterson et al, 2016; Stevens et al, 2016). Stevens et al, (2016) found household food security to be generally poor during the lean season (p=0.006). The study by Steven et al, (2016) which measured food security using the Household Food Insecurity Access Scale (HFIAS), recorded the mean HFIAS score of 4.06± 2.86 SD with a range of 0–13 out of a possible 27. Also, 87.6% of the women were food insecure and 7.7 % were severely food insecure. Moreover, there was a statistically significant difference ((χ^2= 17.312, P= 0·04) on the proportion of participants reporting consumption of lesser meals than desired according to seasons with more reports of food insecurity over the monsoon and late autumn seasons which are dry and/or corresponds to lean season. Most households in the rural areas usually have livelihoods based on farming and the success thereof depends on the rains and/or moisture level of the soils. There seems to be less food in the lean season than in the post-harvest (Sibhatu and Qaim, 2017).

Even with disparities in the amount of food available in the seasons, it is reported that usually there is still not enough to sustain households throughout the year hence the need to use purchased food as contribution to total calorie consumption and nutrient intake.

There is not much known about seasonality and the influence it has on the nutritional status of children and/or any age groups in Botswana. Thus far, the evidence presented from other countries shows that seasonality plays a role in growth status, micronutrient status, haematological parameters, household food security, dietary patterns and STH. This therefore justifies the need for this study to assess the nutritional status of the SAC in Botswana according to seasonality.

Manifestation of nutritional status

As per the framework guiding the current study, the prevalence of underweight, stunting, thinness and OW/OB indicates manifestation of poor nutritional status in the study population. Indicators were derived using anthropometric measurements of weight and height. An elaborate discussion of anthropometry follows.

Anthropometry

Anthropometry studies focus on the analysis of measurements of weight, height and muscle mass to determine the nutritional status of individuals. It is important in indicating the wellbeing of children. There is available work on anthropometry of children; however, there are diverse scopes of these studies that make it difficult to make comparisons.

Some studies use different reference standards such as for the World Health Organization (WHO), National Centre for Health Statistics (NCHS), United States/Centre of Disease Control (US/CDC), Waterlow, Cole et al, International obesity task force (IOTF), Harvard and other country-specific standards (Cole and Lobstein, 2012; Wamba, 2013; Ramos-Sepúlveda et al, 2016; Cochrane et al, 2017; Prakash & Yadav, 2017; Igbokwe et al, 2018). These employ the use of different cut off points and principles, such as use of Z scores standard deviations (SD), percentiles and grading systems.

Vigorous work has gone into the creation of these standards yet some fell short in the use of unrepresentative reference populations of children from the different parts of the world. The study by Barbu et al, (2015) illustrates this very well. This study evaluated the prevalence of obesity and unhealthy behaviours among school children and adolescents from Romania. The researchers opted to use four different classifications, namely for the WHO, IOTF (European based), CDC (US based) and the Romanian reference.

Although the IOTF, CDC and the Romanian references were all within range (24.6%, 25.2% and 22.3% respectively), the WHO produced slightly higher prevalence (31.6%) for the same population group. Likewise, obesity differences were observed using the same references of the WHO, IOTF, USCDC and the Romanian reference at 11.4%, 6.2%, 10% and 12.5% respectively.

Despite diverse references and cut-offs used in research, it is evident that SAC may be struggling with poor growth status. Best et al, (2010) review work on SAC from developing and transitioning countries, showed that the average prevalence of stunting, underweight, thinness, overweight and/or obesity, in SAC when using WHO/CDC reference standards (public health significance rating), were estimated at 20-30% (medium to high), 10-50% (low to very high), 15-35% (very high) and 15-16% (very high) respectively (Best et al, 2010). The highest prevalence for stunting of 20 to 30% was observed in all regions of the world. Underweight prevalence was highest in the western Pacific and African region with prevalence of up to 50% reported. Thinness prevalence was highest in the Africa and South East Asia at approximately 35%. Finally, OW/OB prevalence was highest in the Latin America at a rate of 16%. Additionally, a shift is also evident of a double burden of overnutrition and undernutrition regardless of the economic status of countries, low and middle income included (Tathiah et al, 2013; Jafari et al, 2014; Kroker-Lobos et al, 2014; Khayri et al, 2016; Caleyachetty et al, 2018).

There is limited information on the nutritional status of SAC in Botswana especially those in rural and farming areas. To our knowledge there is only one study that mentions the growth status of children aged 6-11 year authored by Abrams et al, (2003). In this study, it was reported that children who were participants had stunting and thinness prevalence of 8.4% and 6.7% respectively.

However, it is important to note that participants were semi-urban SAC. Also the Abrams' study was an intervention study with children being fed a fortified beverage. The current study therefore will add more knowledge on the growth status of SAC in Botswana but with a focus on the less privileged children residing in rural and farming areas. The study will assess growth status in terms of stunting, underweight, thinness and OW/OB using height for age (H-F-A), weight for age (W-F-A) and BMI for age (BMI-F-A) Z scores.

Immediate Factors

Immediate factors directly influence child growth status. As outlined in the UNICEF framework, these include child dietary intake and child health status. Following is the detailed discussion of these constructs as instructed by the study objectives:

Child's Dietary Intake: meal patterns

Child's dietary intake is discussed under the objective of meal patterns. A meal pattern is an inconclusive concept that tend to describe eating patterns during a mealtime (Leech et al, 2015). Meals differ by type of food consumed, size and/or the frequency in which food is eaten. Literature records different ways of measuring this construct. Some studies use the time of day food is consumed (breakfast 'morning', lunch 'midday' and dinner 'evening') (Erdman et al, 2013; Mwaniki and Makokha, 2013, Leech et al, 2014). Some focus on the type and size of food consumed.

Main meals are a bit large in size and may include more than one food group (starch, protein, vegetables etcetera) whereas snacks are usually small and may include only one food group (Erdman et al, 2013; Nurliyana et al, 2014; Naeeni et al, 2014; Lee et al, 2015; Khayri et al, 2016).

Various tools are used in different studies to measure meal patterns. Some studies use one and/or multiple 24 hour dietary recalls, food frequency questionnaires, food records and self-made questionnaires to measure meal patterns (Erdman et al, 2013, Turyashemererwa et al, 2013, Naeeni et al, 2014, Nurliyana et al, 2014, Khayri et al, 2016). The 24-hour recall method, which is commonly used, allows one to measure food intake over a day's period and may not be as comprehensive as the multiple 24 hour recalls which cover more day of the individual's food intake.

Food frequency is also useful in that food intake and meal patterns are over a longer period usually a month. It also has a wide selection of foods. Food records allow individual to record food intake and record any information as the activity is taking place which can be more accurate than having to recall.

Finally, self-made questionnaires are able to capture experiences as and when necessary and not limiting to information requested. However, with all these methods, it's always critical to choose a method that is suitable to the study population without compromising the usual consumption.

With the use of the different methods already outlined, a dominant trend was observed in the literature that SAC generally exhibited poor meal patterns. It was evident that SAC preferred foods that were fatty, sweet and savoury more than healthy foods such as vegetables and fruits (Mwaniki and Makhokha, 2013; Katungwe et al, 2015; Petrauskiene et al, 2015; Khayri et al, 2016). The poor meal patterns of the SAC increase chances of not meeting the daily recommended intake of certain micro- and macronutrients and consequently cause poor growth status (Mwaniki and Makhokha, 2013; Katungwe et al, 2015; Khayri et al, 2016).

Besides poor meal patterns being caused by SAC eating preference, there are cases where children may not have enough to eat due to poor socioeconomic status in the family especially in the rural areas where resources are generally limited (Christian and Smith, 2018; WHO, 2018b). Persistence thereof in lack of resources in the home may cause increased malnutrition rates. In rural India and more remote areas populated by families of low caste living in severe poverty and where fathers worked as laborers for meagre salaries from unskilled jobs that could barely provide basic needs, high malnutrition rates were observed (53% stunting, 28% severely stunting, 33% thinness, 9% severely thinness, 53% underweight and 26% severely underweight) (Mohan et al, 2016).

Similarly, SAC in Papua New Guinea from poor households that ate less than the minimum dietary diversity recommended by the WHO of less than 4 food groups, presented with severe stunting, moderate stunting, thinness and underweight at 21.2% 57.6%, 12.2% and 48.5%, respectively (Goris et al, 2017).

Due to the inconclusiveness in the definition of the construct meal patterns, the researcher decided to use dietary diversity to define meal patterns. Dietary diversity is defined as the number of food groups presented in the child's diet. Dietary diversity is assessed using the 24-hour dietary recall which is commonly used across nations (Castell et al, 2015). The 24-hour dietary recall is a simple tool with a low response burden. It can also be administered in low literacy populations without compromising the usual consumption of the subject (Burke, 2015; Castell et al, 2015). This was a perfect tool to use in our young study population and parents whom most of have a low literacy rate. Dietary diversity is critical for assessing adequacy of an individual's diet (Sealey-Potts and Potts, 2014).

School age children are in the pre adolescence stage and commonly experiment with food and eating habits which can compromise dietary diversity (Ghate, 2014; Herrador et al, 2015). Zhou et al, (2016) showed that boys 7-10 years who were picky eaters were approximately 2.07 and 2.34 times likely to be thin and malnourished respectively.

Evidence on meal patterns of SAC (6 to 13 years) in Botswana is limited. However, there has been related work on older children attending secondary schools (Maruapula et al, 2011). The study agreed with presented evidence on SAC in developing and developed countries that adolescents in Botswana also preferred high energy dense foods and fewer servings of healthy foods (Maruapula et al, 2011). Such foods may not have sufficient nutrients to support optimal growth and development of the lifecycle.

Brown et al, (2015) conducted a study that is more of a follow up to the aforementioned study and indicated that adolescents' perception of diet is influenced by time (rigidity of school day), location (availability of food in location and social influences) and companions (e.g. peers, school personnel, family); all of which have the ability to influence choice of food (healthy vs. not healthy) consumed.

A pronounced finding of the study was the ability of the participants to choose unhealthy foods despite knowledge of their unhealthy nature (Brown et al, 2015). In a way the study hinted on the ability of children to recognize unhealthy foods from healthy ones yet consumption of unhealthy ones was a conscious decision.

Proof presented hinted to poor meal patterns amongst SAC. It is therefore vital to have early assessments on the meal patterns of this age group to increase the chances of picking problem areas and addressing them on time.

Child Health Status

Child health status is largely connected to child's dietary intake. If the child does not eat a diversified diet that can be able to offer necessary lifecycle nutrients, immunity can be compromised leading to sicknesses and eventually malnutrition. Evidence shows that school age girl children who were often ill were 2.05 and 1.76 times likely to be stunted and malnourished than those who were occasionally ill (Zhou et al, 2016).

Additionally, a child may get sick from other causes such as infection with disease-causing pathogens such as STH which may further compromise immune systems thus increasing the risk of poor growth (Mwaniki and Makokha, 2013). Wolde et al, (2015) showed that the odds of children being stunted increased four times with STH *T. trichuira* infection.

Mwaniki and Makokha, (2013) also found that diarrhoea and colds/cough were positively and significantly correlated to stunting and underweight in children. A sick child may lose appetite, experience malabsorption, nutrient loss and altered metabolism that leads to more growth faltering (underweight, wasted and/or stunted) in the child (Mwaniki and Makokha, 2013; McAlpine et al, 2019; Mulugeta et al, 2019). This may lead to micronutrient deficiencies; the discussion of which follows.

Micronutrient malnutrition

There is widespread micronutrient malnutrition also termed "hidden hunger" worldwide (Gödeckea et al, 2018). Micronutrient deficiencies are called "hidden hunger" because unlike hunger, they are not felt yet they negatively impact one's health and vitality. Even the mildest to moderate form of micronutrient deficiencies can result in mental impairment, poor health, low productivity and mortality if left to persist (WHO, 2018a).

It is estimated that over 2 billion people suffer from micronutrient deficiencies (FAO, 2013). Amongst these are SAC with common micronutrient deficiencies of zinc and iron (Suchdev et al, 2016). A gap exists in the understanding of serum levels of micronutrients in SAC (Amare et al, 2012). This study attempts to bridge the gap by assessing serum iron and zinc in SAC in rural farming communities of Tubu and Shorobe villages. Further discussions of individual micronutrients assessed follows:

Iron

Iron deficiency remains one of the top public health issues around the world (Clénin, 2017). It is estimated that a third of the world's population is affected by anemia and 25.4% of the schoolchildren aged between 5 and 14 years in the world are reported to have anemia (Benoist et al, 2008; Lopez et al, 2015).

Best et al, (2010) in the review on SAC found that in 33 high quality studies from Africa, Latin America, South East Asia and the Western Pacific, anemia prevalence was rated to be in the moderate to severe (between 20 and 40%) range. Despite the limited evidence in Botswana, the possibility of iron deficiency being a problem in the SAC cannot be dismissed.

Iron is an important trace mineral needed by all living organisms, that acts as a component of hemoglobin and myoglobin for oxygen transport and cellular use. Moreover, it also acts as a key functional component in many enzymes for the catalysis of redox reactions critical for energy production (Hirst & Roessler, 2016).

When iron stores become depleted and result in insufficient iron to meet functional needs, iron deficiency (ID) occurs. This process can be summarized in three steps. The first step of ID results when only iron stores (spleen, bone marrow and liver) become depleted and this is detected by decreased serum ferritin (Lopez et al, 2015). Individuals are asymptomatic at this stage.

The second stage is characterised by even lower iron stores, lower circulating plasma ferritin and decreased circulating iron for normal production of hemoglobin (Hb) (Lopez et al, 2015; Nairz et al, 2016). Due to limited iron present, Hb protopophyrin (precursor for Hb) rises and accumulates in the red blood cells (RBC). Equally, transferrin receptors (sTfR) rise on the cell surfaces to allow for up-regulation and better competition for transferrin bound iron (Nairz et al, 2016; Fraenkel, 2018). This stage of ID will be diagnosed in SAC at serum ferritin levels less than or equal to 12 ug/L.

The last stage which is iron deficiency anemia (IDA) is characterized by low blood Hb. This stage in SAC would be indicated by Hb less than or equal to 115g/L and serum ferritin less than or equal to 12 ug/L (WHO/UNU/UNICEF, 2001). At this stage characterization of cells using mean corpuscular volume (MCV) for size and mean corpuscular hemoglobin concentration (MCHC) to indicate Hb concentration in the cell may be used to determine the type of IDA.

Iron deficiency in SAC can be influenced by different factors such as helminthes and protozoa infestations, poor dietary practices, low socioeconomic status and lack of parental education (Florentino et al, 2013; Alelign et al, 2015; Erismann et al, 2017). Helminths and protozoa infestation may result in bleeding of the gut (Arinola et al, 2015; Kuong et al, 2016). Also helminths may be competing for nutrients with the host child as well as being agents of infections (Arinola et al, 2015). Poor dietary practices such as poor intake of iron rich food sources especially of the bioavailable form “heme” and consuming foods with increased inhibitory factors may eventually result in limited iron absorption, leading to iron deficiency (Luo et al, 2011).

Low socioeconomic status, as may be due to employment has been shown to undermine parents' ability to provide healthy food and health care for the child when needed (Luo et al, 2011). It has also been reported that parents with low literacy levels have increased chances of having anemic children. It is believed this follows from lack of appropriate knowledge on the best practices to improve child health (Achouri et al, 2015).

Existing evidence shows iron deficiency to be a problem of public health significance in SAC. This was best captured by Best et al, (2010) in a review of over 369 studies in SAC from over 76 different countries, both in developing and transitioning countries. The researchers looked at 3 levels of iron deficiency namely ID (low iron status), IDA (low iron status + low Hb) and anemia (low Hb). The researchers reported an average prevalence of 19% for ID and Africa alone had a prevalence of 29%. The average prevalence for IDA was 12% whereas anemia using low Hb was estimated at 22%. According to the WHO classification system the world ID prevalence with or without anemia is classified as mild to moderate public health significance (WHO/UNU/UNICEF, 2001). In Africa, the problem of ID was rated as of moderate public health significance (WHO/UNU/UNICEF, 2001).

In Botswana, there is limited work on iron deficiency studies. The Ministry of Health (1996) now Ministry of Health and Wellness conducted a study on the micronutrient status which reported that 43% and 32% of the under-fives and pregnant women were iron deficient. However, iron study works in SAC (6 to 13 years) are limited. So far, only one study by Abrams et al. (2003) captured work on SAC. The study investigated the efficacy of a fortified beverage in improving the nutritional status of children (6-11years) in two primary schools near Gaborone city. The experimental group was given a fruit flavoured beverage containing a blend of micronutrients whereas the control group received the same drink but without micronutrients.

The study parameters included ferritin to determine iron depletion, plasma zinc and MCV. The results showed that 11.6% of the children in the experimental group and 12.1% of the children in the control cohort had low iron stores (Hb 120 g/L or ferritin 33.7 pmol/L). The study further reported other biochemical markers for other micronutrient deficiencies confirming the presence of multiple nutritional deficiencies in this population. It is noteworthy to mention that the Abrams study focused on urban children whereas this study is targeting those living in the rural and farming areas.

Iron deficiency can have negative effects on SAC. These may include poor scholastic performance and low productivity hence studies early in children's lifes are recommended so that prompt interventions can be availed as soon as possible (Perignon et al, 2014).

Zinc

Since iron deficiency is one of the top public health issues worldwide, it follows logic that zinc be studied also. This is because zinc and iron often occur concurrently because they both share food sources. Thus high rates of iron deficiency tend to also predict zinc deficiency (International Zinc Nutrition Consultative Group, 2004). The possibility of zinc deficiency as a problem in the SAC as well and the assessment thereof cannot be dismissed.

Zinc deficiency is said to be a problematic micronutrient deficiency responsible for a substantial disease load in the Eastern Mediterranean, Africa and South-east Asia (IZiNCG, 2004). Like iron deficiency, there is evidence that zinc deficiency is also a problem in SAC. A study using serum zinc concentrations to assess micronutrient status in SAC (6-16 years) found a high zinc deficiency prevalence of 93%. This is a significantly high prevalence even higher than the WHO set 20% prevalence for mandating institution of interventions to mitigate the problem (Benoist et al, 2008).

Benoist et al, (2008) study also reported concurrent micronutrient deficiencies of iron, zinc and iodine, parasitic infestations, and severe stunting in the population group. It is therefore not surprising that zinc deficiency prevalence could be as high as 93%. The study further supports the notion that high anemia and stunting prevalence can also be used as predictors of zinc status (Liu et al, 2017).

Another study that showed that SAC continue to suffer from zinc deficiency was conducted in primary school children aged 7 to 11 years in a settlement of the neighboring country South Africa (Samuel et al, 2010). This study assessed the risk of zinc deficiency in randomly selected children living in a poor South African settlement using serum zinc. The results showed a high risk of zinc deficiency and suboptimal zinc statuses for the majority of the population with 46% of the children with values less than the 70ug/dL (≤ 10.7umol/L) cut-off value (Samuel et al, 2010).

Still in showing the magnitude of the zinc deficiency problem, Best et al, (2010) reviewed 13 studies, 5 of which were of high quality and reported an average prevalence of 46% with ranges from 19-57% from Africa, Latin America and south eastern Asian counties. Zinc deficiency risk factors include poor dietary intake of rich sources, age, sex, seasonality and helminths infestations (Kawade, 2012; Gibson et al, 2011). Older children especially males who are bigger require more zinc for the maintenance of the bodies. Inadequate intake may result in zinc deficiency (Gibson et al, 2011). Gibson et al, (2011) has shown that zinc deficiency is likely during summer season due to accelerated growth in children than winter. As a result, more intake of zinc is needed then. Thus if adequate intake is not met then the rate of zinc deficiency is likely to increase in the summer seasons.

Zinc deficiency may lead to issues such as inhibition of release of other nutrients such as Vitamin A, reduced ability to resist infections, poor growth, poor quality of life and poor academic performance (Kawade, 2012; Amare et al, 2012, Arinola et al, 2015; Vuralli et al, 2017).

To the researchers' knowledge, only one study has assessed zinc deficiency in children of an age group same to this study in Botswana (Abrams et al, 2003). This is the same study that has been discussed in the iron section. It was shown that although there were no baseline zinc values in all groups, low zinc levels were significantly more common in the control cohort (14.5%) than the experimental group (4.6%) at the completion of the study. The high prevalence in the control group than the experimental one is suggestive of zinc deficiency being a health concern in this age group, hence justification for this study.

Soil Transmitted Helminths (STH)

Soil transmitted helminths infestations are reported to be amongst the neglected tropical diseases affecting about 1.5 billion people or 24% of the population globally (WHO, 2019). Some of the at-risk populations include pre-school children with 270 million affected and SAC with 600 million (Hotez & Kamath, 2009; Hotez et al, 2009). Approximately one billion of SAC are estimated to live in endemic areas of STH with about 16%, 71% and 13% from Sub-Saharan Africa, Asia and Latin America and Caribean respectively (Pullan et al, 2014). In SAC, it has been reported that intestinal worms account for 12% of total disease burden (Belay et al, 2011). Generally, children are at higher risk of contracting STH infestations than adults because they are more prone to come into close physical contact with contaminated soil and have poor hygienic practices which exacerbate infections (Novianty et al, 2018).

There are three types of STH and they include *Ascaris lumbricoides* (roundworm), *Trichiuris trichiuria* (whipworm), *Ancylostoma duodenale* and *Necator americanicus* (hookworms) (WHO, 2011; Humphries et al, 2013). More information on the STHs is as follows:

Roundworms *(Ascaris lumbricoides)*

Ascaris lumbricodes (A. lumbricoides) represent one species of STHs causing a significant health problem worldwide amongst the three with an estimate of 1.5 billion people affected (Pullan et al, 2014; Andrade et al, 2016). In terms of distribution, this specie is most prevalent in Oceania (19.7%), Asia (15.8%), Latin America and the Caribbean (LAC) (14.7%), Sub Saharan Africa (SSA) (13.6%) and North Africa and Middle East (5.4%) (Pullan et al, 2014). Children more especially SAC than pre-school children are likely to contract infections and develop clinical manifestation from this helminthes (Belay et al, 2011; Shalaby and Shalaby, 2016). This is so because A. lumbricoides helminths are likely to reach maximum intensity at 5–10 years of age" (Belay et al, 2011). As a result, chronic infection may result and consequently produce infectious agents. These agents may further exacerbate re-infection episodes, worm accumulation and long term sicknesses. The WHO terms the intensity of infection as light, moderate and heavy when eggs per gram of stool are estimated at 1-4999, 5000-49 999 and ≥50 000 respectively.

Symptoms that may persist from infection with A. lumbricoides may include amongst others, abdominal pain, weight loss, diarrhoea, fever and poor mental status (Andrade et al, 2016). Major risk factors for contracting A. lumbricoides include use of compromised water supply, poor hygiene and sanitation practices as well as living in poor socioeconomic areas (Andrade et al, 2016; Shalaby and Shalaby, 2016; Watson et al, 2017).

Of the three STH species, *A. lumbricoides* has high prevalence ranging from over 20% to about 60% (Opara et al, 2012; Amare et al, 2013; Sanchez et al, 2013; Matangalia et al, 2014; Oliveira et al, 2015 and Wolde et al, 2015). By reason of international guidelines, prevalence over 20% with any type of STH calls for preventive chemotherapy (WHO, 2018c). Records of use of either 400mg albendazole and or 500mg mebendazole have been documented with regards to A. lumbricoides STH (Steinmann, 2011). The Frequency of administration, whether annually or biannually depends on the magnitude of the prevalence. For instance, prevalence below 50% calls for a single dose once a year whereas if over 50% it warrants administration to be done twice a year (WHO, 2018d). Studies with lower prevalence with this specie have been recorded. These may be due to regular use of deworming drugs and/or non endemicity of the studied areas to STH (Tulu et al, 2016).

Despite the pervasiveness of this helminth, there is proven evidence of interventions including the use of clean and safe water, good sanitation and hygiene (WASH) practices as well as the use of drugs to reduce if not eliminate A. lumbricoides infections (Adegnika et al, 2014; Levecke et al, 2014; Andrade et al, 2016; Watson et al, 2017).

With the use of WASH practices, a systematic review focusing on whether hand washing interventions would positively change behaviours of children (5-12 years) prone to diarrhoea and STH infections in low to middle income countries was conducted by Watson et al, (2017). Unfortunately, the review found that there was limited good quality evidence on hand-washing promotion interventions on the targeted age group. Nonetheless the study concluded that the effective and cost-effective public health measure of hand washing could possibly lead to significant health impacts (Watson et al, 2017).

On the use of preventive chemotherapy measures, two popular drugs, 400mg albendazole and or 500mg mebendazole have proved to be effective. Studies have shown cure and egg reduction rate ranges of 85% to almost 100% with the use of a single oral dose of these drugs on A. lumbricoides infections (Adegnika et al, 2014; Levecke et al, 2014; Speich et al, 2014).

Whipworms (*Trichuris trichiura)*

Trichuris trichiura (T. trichiura) is another form of STH widely affecting approximately 17% of the world population and or about 604 million people (WHO, 2011). Regional distribution shows prevalence of regions at 12.3%, 11.6%, 7.6%, 6.4% and 1.9% for LAC, SSA, Asia, Oceania and North Africa and Middle East respectively (Pullan et al, 2014). Similarly, to A. lumbricoides, children more especially SAC are likely to contract infections and develop clinical manifestation of this *T. trichiura* because of poor hygiene, sanitation and play practices (Belay et al, 2011; WHO, 2011; Shalaby and Shalaby, 2016). It has been shown to be a risk factor to stunting in SAC most likely because of its chronic nature, being able to inhabit the host gut for more than 3 years (Wolde et al, 2015). There is mild, moderate and severe intensity of infection when helminth eggs per gram of stool are 1 – 999, 1,000 – 9,999 and ≥ 10,000 respectively (Shrestha et al, 2018).

Infestation with T. trichiura may be asymptomatic and/or show symptoms such as abdominal pain, weight loss, diarrhoea (stools may have mucus and blood), inability to empty bowel during defecation, fever and poor mental status among others (Kyung-Sun et al, 2009; Andrade et al, 2016). Risk factors for contracting T. trichiura include use of compromised water supply, poor hygiene and sanitation practices, temperate and warm climates and living in poor socioeconomic areas (Andrade et al, 2016; Shalaby and Shalaby, 2016; Watson et al, 2017).

Evidence amongst SAC also follow a distribution pattern shown by Pullan et al, (2014) that most prevalence of infection with T. trichina may be from LAC, SSA and Asia with highest records even reaching ranges of 70%-97% (Sanchez et al, 2013, Matagalpa et al, 2014; Belisarius et al, 2015; Speich et al, 2014). Such high prevalence warrants for control interventions since prevalence over 20% with any type of STH calls for preventive chemotherapy in addition to promotion of good hygiene and sanitation practices as well as use of clean water (Watson et al, 2017; WHO, 2018d). Literature is consistent with showing that the commonly used oral chemotherapy drugs of albendazole and mebendazole are not enough to achieve efficient cure rate and/or egg reduction rate (Levecke et al, 2014; Speich et al, 2014). For example, in comparison with A. lumbricoides a single oral dose of albendazole could produce a cure rate of 85% and an egg reduction rate of 94% but on T. trichina, one dose produces a cure rate of 40% vs 7% egg reduction rate (Adegnika et al, 2014).

In an attempt to find the best intervention, use of other drugs such as oxantel pamoate has been used (Speich et al, 2014). Speich et al, (2014) showed that albendazole and mebendazole had low cure rates of 2.6% and 11.8% respectively and low egg reduction rate at 45% and 75% respectively. However, when albendazole is combined with another drug of oxantel pamoate, the cure rate and egg reduction rate increased dramatically. Thus the cure rate and the egg reduction rate T. trichina using oxantel pamoate alone were recorded at 26.3% whereas when combined with albendazole it increased to 31.2%. Equally, with egg reduction rates, the use of oxantel pamoate alone increased it to 93.2% whereas when combined with albendazole it became 96% (Speich et al, 2014).

The evidence provided could point to the stubbornness of T. trichiura STH in being eradicated raising a need to have multiple regimens before meaningful efficacy can be achieved. However, this may be a warning to take precautions to prevent against drug resistant STH. Additionally, it is pointing to the need for holistic preventive care for fighting the problem of STH infestations. These may require household members and children to be educated on good sanitary and hygiene practices as well as to promote water cleaning habits.

Hookworms (*Ancylostoma duodenale and Necator americanus)*

The last group of common human STH include hookworms, which have two types, namely *Ancylostoma* duodenale (A. duodenale) and *Necator americanus (N. americanus)*. This group of STH has even higher implications on health. The nature of this species is that it attaches itself to the gut of the host and feed from it causing chronic blood loss and ultimately iron deficiency anemia and malnutrition (Ketema et al, 2015; Bartsch et al, 2016). This explains why it is rated second after malaria in its impact on child and maternal health. Close to 740 million people suffer from hookworm infections (CDC, 2013). There are differences between these two species. *A. duodenale* is able to cause more symptoms and harm with a small load as compared to *N. americanus* (Ketema et al, 2015). Per worm basis, infection with *A. duodenale* may cause about five times more blood loss quickly resulting in iron deficiency than its counterpart (Ketema et al, 2015).

With focus on the distribution, hookworms are more prevalent in the regions of Oceania (47.9%), SSA (13.6%), Asia (7.5%), LAC (5/2%) and North Africa and Middle East (1.0%). Unlike other STHs, hookworms' high intensity infection affects all age groups in low and middle income countries (Bartsch et al, 2016). Nonetheless children who are still growing are a concern group. It is not uncommon to register prevalence of close to 50% and above in SAC (Opara et al, 2012; Degarege et al, 2013).

According to WHO (2002), mild, moderate and severe intensity of infection with any of the hookworm types is when eggs per gram of stool are 1 – 1,999, 2,000 – 3,999 and ≥ 4,000 respectively.

As with other STH, SAC are prone to contracting hookworm due to compromised hygiene and sanitation practices and use of unclean water (Klemm et al, 2015). Infections are exacerbated when there is open defecation from someone who is infected consequently polluting the environment. Additionally, if the environment is also optimal at supporting hookworm larvae growth through warm and adequately moisture soils, then anyone walking barefooted may be exposed as the larvae penetrate the skin (Sahimin et al, 2017). School age children enjoy playing barefooted. Ketema et al, (2015) showed that children who at times played barefooted were twice more likely to be infected with hookworms. Because of the dire consequences posed by infection with hookworm, specifically of blood loss, iron deficiency anemia and malnutrition, global efforts have been put in place to reduce if not to eliminate the occurrence of infection.

In addition to promoting the use of safe water, good hygiene and sanitation practices, preventive chemotherapy is also in use (Klemm et al, 2015; Watson et al, 2017). Commonly used drugs, albendazole and mebendazole, have moderate effects on reducing egg counts and curing hookworm infections (Levecke et al, 2014). Nonetheless, of the two drugs, albendazole has better efficacy (Levecke et al, 2014). Despite the moderate effect, when the doses are increased through a 3-day regimen, the efficacy may increase (Adegnika et al, 2014).

Other attempts towards finding preventive chemotherapy that are simple, cost effective, time efficient and with economic impacts are underway. Such include the development of hookworm vaccine for use in high transmission settings (Bartsch et al, 2016).

Just like flu shots, this vaccine may just facilitate the elimination of STH specifically of hookworm to ≤ 1% of moderate-heavy intensity (WHO, 2012).

There is limited public health research on STH in Botswana. To the author's knowledge there are no studies on STH infestations in SAC. Only one national survey conducted in 1996 by Ministry of Health (MoH) now Ministry of Health and Wellness showed that parasitic infestations in children (pre-school) were prevalent. The survey showed that out of 213 children who had stool samples analysed, 38% presented with parasites. Within those infected, 52% presented with G. lambia, 27% with H. nana and 15% with hookworm (MoH, 1996). It is important to note that the study examined intestinal parasites irrespective of whether they were soil and/or water transmitted.

Poor sanitation may contribute more to transmission of STH in Botswana. To date there are still populations within Botswana with low to no safe sanitation services (Statistics Botswana, 2015a, 2015b). This usually occurs in the rural areas where poverty seems to prevail more (Statistics Botswana, 2018). Tubu and Shorobe are rural areas, in the Ngamiland district of Botswana where many people still live in unfavourable conditions of poverty. As an example most of the households do not own toilets and thus have to go to the bush to defecate. Ngamiland East and West have 73.4% and 39.0% of households with access to improved methods of waste disposal respectively. This implies a certain percentage of people that may be resorting to the use of other means such as the bush (Statistics Botswana 2015a; 2015b).

Excreta waste may contaminate the soil. As a result, larval penetration of helminthic parasites into any part of the skin exposed to contaminated soil may result. Consequently, this can impact health, growth and nutritional status of the affected population especially children who may be helping parents at the fields.

There is ample evidence pointing to the negative consequences of STH infestations on SAC. It is therefore important to detect STHs early in children so as to develop necessary, appropriate and preventive measures to improve the nutritional status and wellbeing of the children.

Relationship between STH and iron status

As articulated in the literature review of STH, the relationship between STH and iron status is an important one and needs attention in the SAC. It has been estimated that about 12% of SAC are likely to be infested with intestinal worms (Belay et al, 2011). Major risk factors for infestation with intestinal worms and/or STH amongst SAC is close proximity with contaminated soils when playing, poor hygiene and sanitation practices, use of compromised water supplies as well living in low socioeconomic areas (WHO, 2011; Andrade et al, 2016; Shalaby and Shalaby, 2016; Watson et al, 2017).

Chronic infection with STH result in symptoms such as diarrhoea, abdominal pains, fever, loss of appetite, loss of weight, blood loss and poor mental status (Andrade et al, 2016). In severe cases and where infestation is with hookworm resulting in chronic blood loss, ID may occur (Ketema et al, 2015). The type of hookworm is even important as *A. duodenale* is able to cause blood loss five times more quickly with a small load than *N. americanus* (ketema et al, 2015).

Information on the relationship between STH and iron status is scanty in Botswana. However, the possibility of the study population being affected by both STH and ID cannot be laid off. This is because the environment they live in puts them at risk. For instance, the Ngamiland district’s rating as one of the poorest already puts the children living there at a disadvantage (Statistics Botswana, 2018).

Poor hygiene and sanitation practices of having no toilets and using the bush further increase vulnerability to infestation with STH (Masamba, 2009). Also helping in the farm where there is a high possibility of contact with contaminated soil may put SAC in rural areas at more risk of infestation with STH. The importance of a study on the relationship between STH and iron status cannot be dismissed if child welfare is to be prioritized.

Underlying Determinants

This second layer of the determinants appreciates that child nutrition, caregivers and household characteristics have a role in the wellbeing of the child. The status of the aforementioned may directly influence the immediate factors particularly the dietary intake and health status of the child to determine the final outcome of the child's nutritional status (UNICEF, 1990; Smith and Haddad, 2015). Household food security status, caregiver characteristics (important for showing the ability of the caregiver to take care of the child) and health environment and services around the child are further discussed towards child wellbeing.

Household food security

Household food security is defined as the ability of the household to have both physical and economic access to sufficient, safe and nutritious food at all times to meet dietary needs and food preferences for an active and healthy life of all members of the family (USAID, 1992). On the contrary, household food insecurity describes the inability of the household to have access to nutritious and safe food acquired in socially acceptable ways due to lack of and/or limited finances and/ or other resources (USDA ERS, 2017).

Food insecurity is a major problem in the world despite sufficient food supplies (Berners-Lee et al, 2018). About 2 billion people in the world are estimated to be moderately to severely food insecure (FAO/IFAD/UNICEF/WFP/WHO, 2019). More and more people are being undernourished as a result. So far 815 million people were reported undernourished in 2016 from 777 million in 2015 showing an accelerated problem of deprivation (FAO/IFAD/UNICEF/WFP/WHO, 2017). The problematic regions as of 2016 include Africa (20%), Asia (11.7%), Western Asia and Northern Africa (9.5%) and Latin America and the Caribbean (6.6%) (FAO/IFAD/UNICEF/WFP and WHO, 2017). Southern Africa alone, a sub region, has a prevalence of 8.0% indicating a pronounced problem of food insecurity in Southern Africa.

Food insecurity information in Botswana is limited. Thus far, although Botswana is classified as an upper middle income country, few reports available show that households still have food security challenges. It has been estimated that household food insecurity prevalence in the country for the period of 2015/2016 was 38.9% (Statistics Botswana, 2018). The high prevalence of food insecurity could emanate from such shocks as dry spells, high temperatures and resultant crop failures. All these have a possibility of escalating the prevalence of poverty in the rural areas (Moseley, 2016).

Available literature has shown persistence of poor nutritional status on children residing in food insecure households around the country (Nnyepi et al, 2010). The Ngamiland District despite its abundant resources seem to be rated amongst the poorest. This could indirectly point to the severity of food insecurity in the study area.

Since food security is a broad concept, there are several tools used to assess it (Bickel et al, 2000; USDA ERS, 2006; Coates et al, 2007). These tools measure different dimensions of food security, which includes availability (food sources, agricultural production), accessibility (assets, income and expenditure, food frequency, food diversity, feelings of deprivation and coping strategies) and utilization (sanitary/hygiene practices; water sources) (USDA ERS, 2006; Coates et al, 2007). Also captured may be experiences of hunger, food aid and feelings of shame when using socially unacceptable means to attain food resources (Coates et al, 2007).

The development of the tools is influenced by factors such as the audience characteristics (youth/adult) specific purpose of the tool, duration of food insecurity that is being assessed, etc. Consequent to these factors, some tools are shorter (few items) than others (USDA ERS, 2006; Coates et al, 2007). These differences have advantages and disadvantages. The short and simple tools are good to use with children because they reduce response burden. However, they may leave out other important information (USDA ERS, 2017). In terms of recall span, there is need to assess why the information is collected in order to choose the appropriate span. The shorter the span of the experiences measured, the better the recall memory. The longer the span of the experiences, the more helpful the results will be in understanding the phenomena.

Even with many measuring tools, the most commonly and preferred tool thus far seem to be the HFIAS developed in the United States of America (Coates et al, 2007). What sets this tool apart from the rest, is its ability to be adapted to local settings of other nations globally. Furthermore, it is not long and has only nine questions yet able to capture experiences of food insecurity such as anxiety over food supply and any coping strategies practiced when the shortage of food intensifies.

Additionally, it uses the recall period of four weeks which is short enough for respondents to remember. This study uses this tool mainly because it has been used successfully in African settings in addition to the above mentioned advantages (Gebreyesus et al, 2015).

Clearly, food insecurity at any level tends to have deleterious effects. Household food insecurity with or without hunger has been shown to be associated with adverse health issues such as diabetes, hypertension, anemia and general poor health that may lead to frequent hospitalizations (Seligman et al, 2010, Pirkle et al, 2014). For children, hospitalizations result in school absenteeism, which will eventually affect child performance at school (Tamiru et al, 2016). Evidence also shows that early exposure to food insecurity could result in poor growth as shown by low height for age and weight for age (Wolde et al, 2015; Alipour et al, 2016; Humphries et al, 2017). For instance, Pirkle et al, (2014) conveyed that children (8-15 years) who were food insecure lost about half a year growth in height, on average being about 2cm shorter than those that were food secure.

Another instance where food insecurity affected dietary intake patterns was illustrated by Sharkey et al, (2012) in the work with children of Mexican origin living in poorer conditions in Texas, USA. The authors revealed that food insecure children, tended to have poor eating habits such as consuming more energy and having a greater percentage of the calories from fat and added sugars. This may be because these foods tend to be cheaper yet less nutrient dense. Thus limited food and/or resources to procure nutritious and safe food may impact dietary intake patterns leading to certain nutrient deficiencies which may compromise the response of the child to infections ultimately the nutritional status (Pirkle et al, 2014; Lee et al, 2015; Tamiru et al, 2016).

Caregiver characteristics and influence in child nutritional status

Literature seem to be in agreement with the conceptual framework of the child's nutritional status which shows that caregiver characteristics are underlying factors that influence the child's dietary intake and/ or health status (UNICEF, 1990; Smith and Hadaad, 2015). It has been shown that the empowerment of the woman or mother and/or caregiver whether through education and/or finances is crucial towards the ability to make favourable decisions regarding the child's health (Babar et al, 2010; Herrador et al, 2014; Khayri et al, 2016). When the caregiver has the right resources, they may decide to have a more proper way of exposing excreta such as a flush toilet, may promote healthy eating and living in the home and/or take the child to seek right help when sick (Babar et al, 2010). Petrauskiene et al, (2015) found that when parents had higher education and income, children tended to consume breakfast daily and have increased fresh fruits intake. On the contrary, Wolde et al, (2015) showed that when the child had poor hygiene practices and the mother did not have any formal education, the child was likely to have faltered growth.

Health environment and Services

How healthy the environment is around the child, is essential to the wellbeing and/or health status of the child. A child who lives in an environment that does not promotes good hygiene and sanitation practices, is likely to be malnourished. This is so because the child is at high risk of contracting diseases and pathogens such as STH that may eventually cause them to be sick (Feleke, 2016). The more the sickness persists in the child and proper help is not sought, the higher the likelihood of stunting, thinness and/or underweight (Mwaniki and Makhokha, 2013)

Factors influencing SAC nutritional status

School age period is a very critical time in that children begin to develop physically, socially, psychologically and learn many concepts and habits that will influence adulthood. As a result many factors are likely to influence SAC's nutritional status. For instance, Mwaniki and Makokha (2013) state that malnutrition among school-age children is a resultant of "inadequacies in one or more of the three main preconditions for good nutrition which are food, care and health". This is supported by other studies in the literature. For example, a study determining malnutrition correlates among rural primary school children in Fogera District, Northwest Ethiopia found that school children living in large families with over 6 members were 2.4 times more likely to be underweight compared to those in smaller households. This could point to the division of resources amongst many family members, compromised care and/or poor feeding practices (Mekonnen et al., 2013). Further, the study showed that school children who had infections and had no latrines were 4.3 and 1.5 times more likely to be underweight and thin respectively indicating lack and/or inadequate health care services and or poor health care practices.

Other studies show that socioeconomic and family environment factors are important in predicting nutritional status of SAC. For example, it has been shown that as income decreased, chronic food insecurity increased amongst adolescents aged 13-17 years (Belachew et al., 2012). Additionally, the study showed that female headship in the household, illiteracy of parents and number of dependents compared to income earners influenced chronic food insecurity in the children.

Another study also agreed as it showed that the social status of the mother defined by literacy, occupation, monthly income and diet knowledge were highly significant in predicting malnutrition among SAC aged 4-14 years in the Western Nepal (Joshi et al., 2011).

Other studies found all factors (health-, care-, food-, socio-economic- and family related predictors) to be critical in predicting nutritional status of the SAC (Sekumade, 2013; Wolde et al., 2015). An example of this is a study conducted in Nigeria among children 5-11 years (Sekumade, 2013). It was shown that the hygienic status of the dwelling environment predicted the children's body mass indices and weight for height measures. Also household size, income earned by other members of the household, mother's income had a positive effect on the weight and height of the children (Sekumade, 2013).

However, other studies failed to agree with the view that malnutrition in SAC is due to inadequacies in food, care and health but concluded that there were complexities in risk factors influencing nutritional status which may be contextual such as pertaining to culture and country of origin and/or environmental (Manyanga et al., 2014). Such risk factors also need close examination for accurate assessments.

To the best of our knowledge there is no evidence on factors determining nutritional status of SAC (6 to 13 years) in Botswana especially in rural farming areas. But a vast literature exists in factors predicting nutritional status in children under the age of 5 years in Botswana (Mahgoub et al., 2007; Kadima, 2012). With conflicting evidence on the factors influencing SAC's nutritional status, we find it appropriate to assess those that might be influencing SAC (6 to 13 years) in rural farming areas of Botswana. This information is necessary to develop appropriate and relevant malnutrition counteractive strategies or programs for this group.

In conclusion, evidence presented throughout the work suggests SAC as a vulnerable group to poor nutritional status. It further shows the interrelationships of a vast number of factors directly and indirectly contributing to the child's nutritional status and/or wellbeing.

The limited information on SAC that can lead to conclusions on the situations of the children in Botswana is a concern. SAC are at a developmental stage which is a critical point of physical, social, psychological and mental growth. More work is therefore needed to understand nutritional status to ensure desirable growth and development.

CHAPTER 3 METHODOLOGY

Study Design

The study was a cross sectional study design. The choice of the design was informed by literature indicating that cross sectional studies are best used when describing the prevalence of an outcome of interest at one point in time (Levin, 2006; Alexander et al, 2015). It was further stated that this same design can be repeated with same subjects and/or different ones to create a pseudo longitudinal study. Since the current study sought to assess the nutritional status of the children in the study sites and give a picture even as influenced by two seasons of lean and plenty, it was found suitable to use the cross sectional study design. It was important to collect data twice to capture seasonality and how flooding affect food security, health and nutritional status of children. Furthermore, due to the nature of the study which involved seasons and flooding patterns, mixed methods in data collection and analysis were utilized. For instance, data collection methods included both qualitative (participatory rural appraisal (PRA) reports, observation and interviews) and quantitative (hypothesis testing, surveys and precise measurements to get data) methods were used to help explain the picture of SAC's nutritional status in their respective farming systems. For validity, statistical testing (quantitative) and use of PRA reports, existing scientific literature and observation (qualitative) assisted to give interpretation of results. Evidence in children would assist to capture how the overall *molapo* and *non-molapo* farming communities fared health-wise despite the shock of flooding which influenced many health aspects.

Study Population and Sampling Frame

The study focused on children aged between 6 and 13 years, residing in the Ngamiland District but living along the fringes of the Okavango Delta, Botswana.

The region has a wide range of flooding patterns and variations supporting both *molapo* and dry land farming. The study concentrated on children 6 to 13 years in the Ngamiland District as the reference population, children 6 to 13 years from *molapo* and *non-molapo* farming households as the study population and list of children 6 to 13 years from *molapo* and *non-molapo* farming households of Tubu and Shorobe villages as the sampling frame. A child of 6 to 13 years and his/her respective caregiver from *molapo* and *non-molapo* farming households of Tubu and Shorobe villages were considered as the study units (Table 1).

Table 1 Study sampling frame

Reference Population	**Study Population**	**Sampling Frame**	**Study Unit**
Children 6 to 13 years in Ngamiland District	Children 6 to 13 years in *molapo and non-molapo* farming households	List of children 6 to 13 years in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages	A child 6 to 13 years in *molapo* and *non-molapo* farming households of Tubu and Shorobe villages

Sampling size estimation

Two lists of children (6 to 13 years) in both *molapo* and *non-molapo* farming households in Tubu and Shorobe villages were generated from the clinic and school registries and through house visits by the researchers who worked alongside Village Development Committee (VDC) members and Community Research Assistants (CRAs).

Together the lists had 375 children with 265 and 110 children from Shorobe and Tubu villages respectively (Table 2). To calculate for a statistically acceptable sample size for a population of 375, statistical sample determination software, Rasoft (2004) was used (Rasoft Inc., 2004). At 95% level of significance and allowing error margin of 5%, the software indicated that the appropriate sample size would be 191.

An additional 10% of the sample was then added to cover those in the original sample that may be unavailable or reluctant to participate in the study. It was finally determined that the needed study sample size of 210 (N=210) would suffice. To determine how many child participants were needed per village, the sample size of 210 was allocated to the two villages using proportional-to size sampling scheme where the size represented the number of children per village (Skinner, 2014). It was shown that 148 and 62 children were needed from Shorobe and Tubu respectively (Table 2).

To choose child participants per village, all children in the respective lists were given number codes. The coded lists were then entered into Rasoft software and using simple random sampling method which gave every child a chance to be chosen, 148 and 62 child participants were chosen. The simple random sampling was without replacement. This meant that if the chosen number was repeated, it would be ignored and more numbers chosen.

The study had a subsample (for blood work) (N=66) for micronutrient (zinc and iron) study. Due to the limitation in resources and the rule of thumb that having a sample size over 30 can produce a statistical effect, the researcher set to have at least 30 children per farming system (Martinez-Abrain, 2014). These were subsampled from the already chosen list of 210 (148 and 62) children 6 to 13 years from Shorobe and Tubu respectively. These lists were grouped into farming types. Tubu had all the children coming from *molapo* farming whereas Shorobe only had 11 as *molapo* and the rest being 137 from *non-molapo*.

To determine how many child participants were needed per village and farming system, the sample sizes of the respective farming types were allocated using proportional-to size sampling scheme. The sample sizes were allocated proportionally as follows:

a. Tubu: 62 *molapo* children/ 210 children * 66 expected target=19 *molapo* children

b. Shorobe *molapo* children: 11 *molapo* children/ 210 children *66 expected target =3 children BUT all 11 were included because of the small number). Total *molapo* children needed were 30

c. Shorobe *non-molapo*: 137 *non-molapo* children / 210 children * 66 = 43 children. Since we had 30 *molapo* children this meant we had to make an exception to get only 36 from *non-molapo* instead of 43.

Thereafter, to choose child participants per village and farming system, all children in the respective lists were given number codes. The coded lists were then entered into Rasoft software which used simple random sampling method without replacement to choose participants. Exceptions had to be made in the subsampling because of the dominance of farming types practiced per village. For instance, Tubu predominantly practiced *molapo* farming whereas Shorobe *non-molapo* farming. Overall, determined sample size for the main study was 210 whereas for the subsample micronutrient study it was 66. Due to the difficulty of getting children consented to participate in the study during the first season, the researcher decided to repeat the same sampling process for season two. This meant that it was not a guarantee that the same children who participated in the first season study would be in the second season study. However, because of the overall small sample of the SAC in the study sites, it could not be avoided that some of the children may appear in both seasons.

Sampling of child participants was on the basis of village and farming type only because this fed into the mother project, Botswana Ecohealth Project. Since the project dealt with under-fives and adults, this study sought to close a gap and study children in the next lifecycle after preschool. Age was not factored into sampling process in the intial stages but after sampling was conducted by village and farming type. Due to some individual age categorization having < 30 children during some seasons, the researcher decided to conduct analysis by wider age groups (6 to 9 and 10 to 13 years) instead. A sample size over 30 was deemed sufficienct to produce a statistical effect (Martinez-Abrain, 2014). Evidence showed that developmentally, children at these age groups have growth similarities; hence zinc and iron cutoff references follow the same groupings (WHO, 2009).

Furthermore, children were sampled on individual bases and followed to households where caretakers were also interviewed. This implied that it was possible to have more than one child per caretaker.

Table 2 Sample size allocation per village using proportional-sampling scheme method

VILLAGE	SHOROBE	TUBU	TOTAL
POPULATION	265	110	375
SAMPLE SIZE	265/375*210=148	110/375*210=62	210

Inclusion criteria

The study included children from *molapo* and *non-molapo* farming households between the ages of 6 and 13 years and who resided in the study villages of Tubu and Shorobe in Ngamiland District of Botswana. Both male and female children were allowed to participate. Final participation in the study was by parental consent and child assent.

Exclusion criteria

For ease of access, only children in the age range of 6 to 13 years, residing within the study villages were included. Children in nearby villages and/or settlements were excluded from the study.

Assumptions

The study operates under one encompassing assumption that the usual flooding patterns normally observed in the villages at the specific seasons will occur. This will help capture the true nutritional status of the children on the respective lean and plenty seasons.

These flooding patterns if they occur as usually experienced, then a true picture showing their impact on growth status, dietary patterns, micronutrient status, STH prevalence and food security status may be observed. This way, timely and appropriate solutions and strategies may be put in place to help in the improvement of the children's nutritional status as well as that of the communities they live in.

Delimitation of the study

This study was delimited to the nutritional status of the SAC (6 and 13 years) in rural farming communities of Tubu and Shorobe villages in Ngamiland District of Botswana. It also assessed nutritional status as influenced by seasonality and farming system. The nutritional status assessment focused on six areas namely, anthropometric assessment, micronutrient malnutrition (zinc and iron), dietary intake patterns, household food security status, prevalence of soil-transmitted helminths and the relationship between STH and iron status.

Study Areas

The study was conducted in two villages, Tubu and Shorobe (Figures 2 & 3), which are situated on the fringes of the Okavango Delta, Botswana. The sites provide a range of flooding patterns and variations in *molapo* farming practices. The study villages are discussed extensively in the following paragraphs.

Tubu village

Tubu village is situated in Ngamiland West Sub-district; approximately 10 km east of Gumare and lying on the banks of the Thaoge River (Figures 2 & 3). It experiences some flooding that occurs every year despite variation in flood extent. When floods occur and recede then *molapo* fields are cultivated taking advantage of moisture from high water table. The population of Tubu village was estimated at 483 in 2011 (2011 Census) from 754 (2001 Census) showing a decrease in the population (Statistics Botswana, 2001, 2011). The village has a Chief and tribal administration offices. A VDC exists to guide development planning and implementation in the village. The village has a health post staffed with a nurse and a health education assistant. There is an Agricultural Demonstrator (based in Gumare which is approximately 10km from Tubu) who works with a village based Farmers' Committee (FC) to promote sustainable crop production methods. The village is also serviced by a social worker who is also based in Gumare village. The major source of livelihood in Tubu is agriculture (both crops and livestock).

Shorobe village

Shorobe village (Figure 2 & 3), also a study site, is in the Ngamiland East Sub-district and about 36 km northeast of Maun. It has extensive networks of *molapo* fields fed by the Santantadibe and Gomoti Rivers and by backflow from the Thamalakane River. Despite being fed by these three rivers, Shorobe experiences periodic flooding whereas Tubu experiences frequent flooding.

Flooding of most *molapo* fields in this village has not occurred for several years until flood waters returned around the year 2009 (Molefe et al, 2014). Shorobe village has a population of 1,031 (2011, Census) from 955 (Census 2001) which shows an increase in population compared to Tubu (Statistics Botswana, 2001, 2011). The villagers practise both arable and pastoral farming. They also engage in traditional beer brewing and palm wine making, fishing and basket weaving. The village has a Chief and tribal administration facilities. Other village level institutions include Village Development Committee, Farmers' Committee and a Community Trust dealing with community based natural resource management (CBNRM) activities. As a relatively large village, there are a range of facilities including a primary school, a clinic with maternity ward (staffed with two nurses and a Health Education Assistant), and several extension staff (Social Welfare Officer, Agricultural Demonstrator and a Veterinary Assistant).

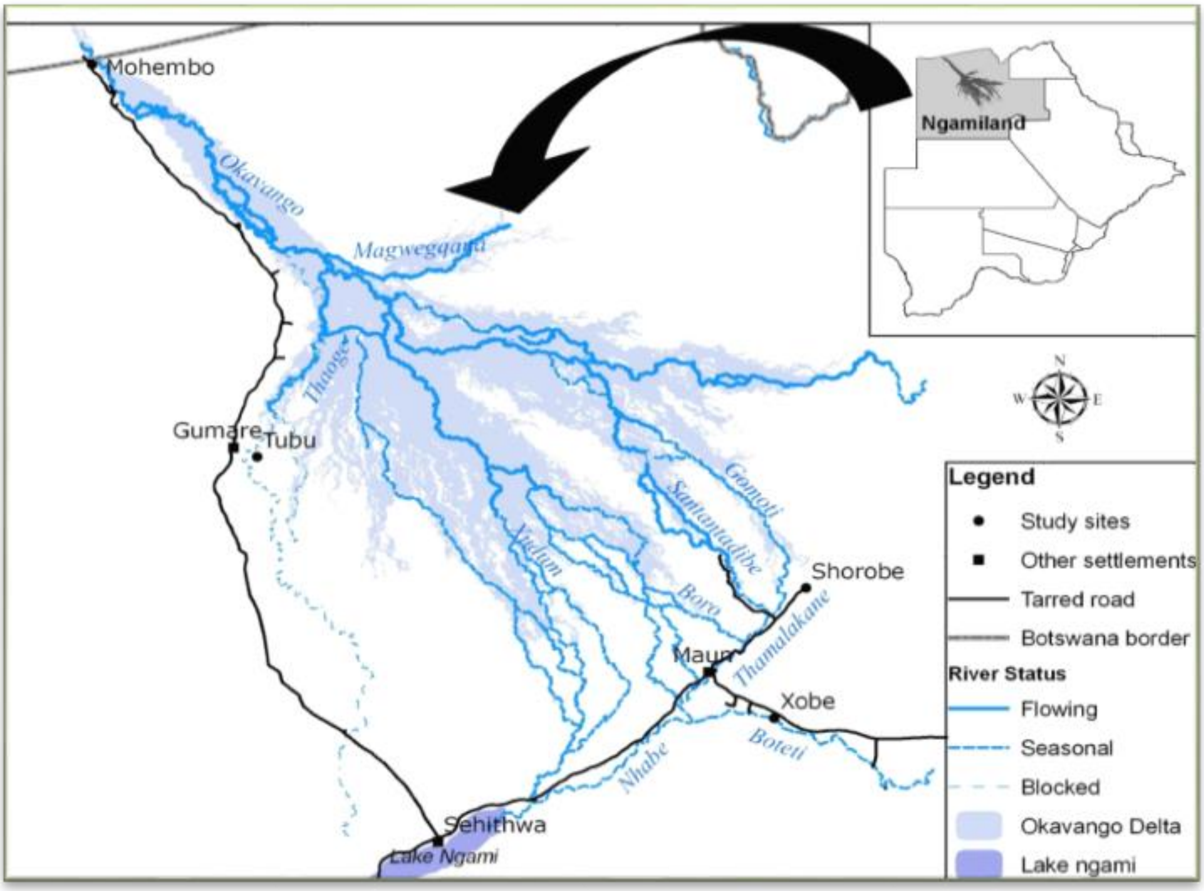

Figure 2 Study sites of Tubu and Shorobe villages from the context of Ngamiland District, Botswana. Source: Botswana Ecohealth Project, 2010

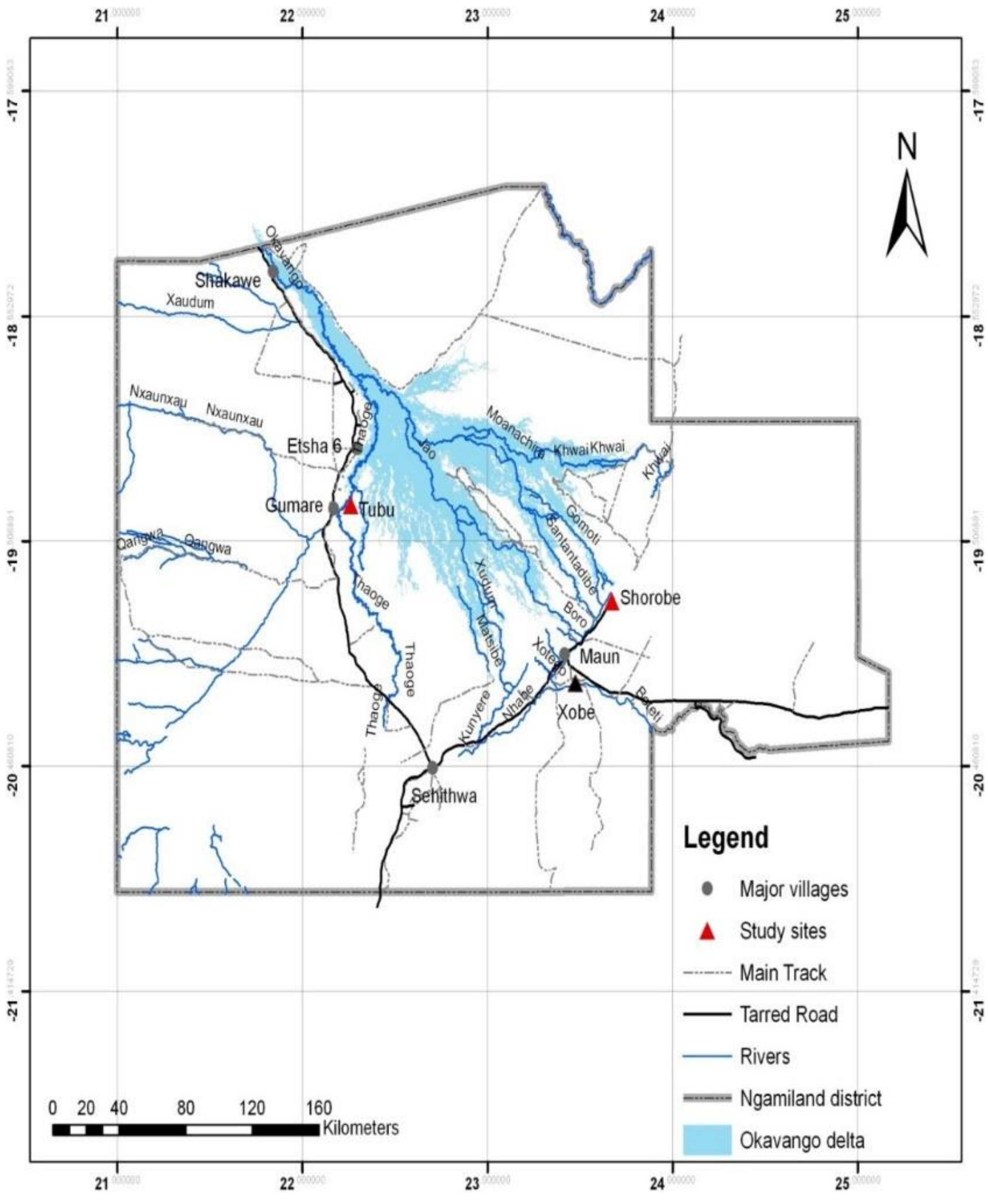

Figure 3 A closer view of study sites as placed in the Okavango Delta Panhandle in the Ngamiland. Source: Botswana Ecohealth Project, 2010

Data Collection Procedures

Types of data collected & Tools used

The different types of data collected in the study and their respective tools are as follows:

- Sociodemographics and factors influencing nutritional status: socioeconomic survey questionnaire
- Meal patterns: interviews on caregivers and children on food consumed in the past 24 hours (Swindale & Bilinsky, 2006)
- Serum iron and zinc status: blood drawn through venepuncture (WHO, 2010)
- Soil transmitted Helminths: Active parasitological survey (WHO, 1994)
- Household Food Security: interviews on household heads responsible over food and aged above 18 years on household food insecurity conditions in the past month (Coates et al, 2007)

On the basis of available data which were normally distributed, Independent samples T-tests (parametric tests) were used in the study. The tests were chosen because dependent variables such as WAZ, HAZ BAZ, Hb, ferritin, zinc etc. were continuous whereas corresponding independent variables were categorical. Furthermore, there were two independent groups that were compared (e.g. lean vs plenty; 6 to 9 years vs 10-13 years and molapo vs non molapo). Thus the children and/or caregivers in each of the two groups compared were different. Lastly, the variances of the two groups measured were equal in the population. Other tests were also employed like Chi square statistics where data were nominal such as was seen when assessing factors influencing nutritional status and using the binary logistic regression. More thorough explanations of statistical tests chosen is as follows:

Anthropometry

Hypothesis: There are no significant differences in the WAZ, HAZ and BAZ means according to seasons, farming types and/ or age group.

Variables: *Dependent*: Prevalence of stunting, underweight, thinness and overweight and obesity as indicated by height for age, weight for age and BMI for age z scores. *Independent*: Seasonality, age groups and farming type

Statistical analysis and test (s): Height and weights were converted to z values using the WHOAnthro Plus Software and exported to SPSS for further analysis and hypothesis testing. Cut off points of the indicators were applied to the data to categorize children into stunting (height for age Z scores below -2 SD), underweight (weight for age Z score below -2SD), thinness (BMI for age Z score below -2 SD), and overweight and obesity (BMI for age Z scores ≥ +1SD) (WHO, 2009). Thereafter, frequencies and respective percentages were used to report prevalence of stunting, underweight, thinness, overweight and obesity.

Hypothesis testing: HAZ, WAZ and BAZ means were compared according to seasonality (lean vs. plenty), age (6 to 9 years vs. 10 to 13 years) and farming type (*molapo* vs. *non-molapo*) using the Independent Samples T test. On Significance was established at *p*-value <0.05.

Instrumentation: Height was measured using a Seca 217 height stadiometer whereas for weight a digital body composition scale (EKS 9800SV) was used. These tools were calibrated prior to use. Height and weight measurements were taken by the researcher and trained CRAs.

Data collection: Using an assembled Seca 217 height stadiometer placed on a level ground, children were asked to have light clothing on, remove shoes and socks and stand straight underneath the head plate. Children were then encouraged to stand with feet flat on the centre of the base plate, feet together and heels against the rod with the back standing straight as possible, preferably against the rod, and the arms hanging loosely by the sides and facing forward. The measuring arm was then placed above the child's head, moving and adjusting the child's head so that the Frankfort Plane was in a horizontal position for an accurate measurement. Firm but gentle upward pressure was applied lifting the child's head upwards towards the stadiometer head plate and thus stretching the child to the maximum height. Jerky movements were discouraged.

The procedure was explained to the child as it was being performed, which assisted with cooperation. An assistant helped to lower the head plate down gently onto the child's head, making sure that the plate touched the head and that it was not pressing down too hard on the child's head. Still holding the child's head, traction was relieved and the child was allowed to stand relaxed. The height value was read to the nearest 0.1 centimeter (cm). The procedure was repeated for second reading and the average finally used (WHO, 2008).

Weight: Each child was asked to remove shoes, heavy outer garments such as jackets, cardigans and to empty pockets. Weight was taken using a digital body composition scale (EKS 9800SV). Using a foot, the scale was switched on by pressing the top of the scale waiting for a display of 0.0 kg before the child stood on the scale. The child was then instructed to stand with feet aligned on the metal plates where it was depicted to place them. They were also instructed to have arms hanging loosely at sides and head faced forward.

The child was then asked to look forward and avoid temptation of reading the weight. Immediately doted flashing lines appeared to enable one to enter personal data such as child code, gender, age, height and daily activity level. After data had been entered, analysis commenced until body composition indicators including weight appeared on the screen and were stable, then the weight was recorded. The child was asked to step off the scale whilst it was reset to 0.0 kg again for second analysis and weight reading. Since identification data for the child was stored in the scale memory, the second weight reading occurred immediately. The average of two readings was recorded in kilograms to the nearest 0.1 kg (WHO, 2008).

Dietary Patterns

Hypothesis: There are no significant differences in the mean HDDS when compared by season, age groups and/ or farming types

Variables: *Dependent*: Dietary diversity (number of food groups represented in the child's diet) and dietary diversity scores. *Independent*: Seasonality, age groups and farming type

Statistical analysis and test(s): Respondent responses were entered into SPSS and coded as suggested in Swindale and Bilinsky (2006) to create a variable for each household (0-12). Thereafter, dietary diversity in terms of food group representation in children's diets in the past 24 hours was calculated. Cross tabulation analysis was used to estimate prevalence which was reported in percentages (%). To calculate the dietary diversity scores, responses were tabulated according to Swindale and Bilinsky (2006). In the matrix, the higher the score the better the dietary diversity would be. Scores were reported as means ± SD.

Hypothesis testing: Mean HDDS were compared according to seasonality, age and farming type using the Independent Samples T test. Significance was established at *p*-value <0.05.

Instrumentation: A Household Dietary Diversity questionnaire (HDDS) by Swindale and Bilinsky (2006) which measured dietary diversity of the children in the previous 24 hours was used to describe what constituted diets on a typical day. Although it may seem inappropriate to use the HDDS tool which shows the economic ability of a household to access a variety of food instead of the IDDS which is reported to show the nutrient adequacy of the diet of individuals, the researcher decided to use the HDDS to describe what children's meals comprised of. This choice was made on the basis that i) in the study setting; children consume everything offered at the household level. Therefore, children could not be separated from the households. Even interviews took part at home with the caregivers and the children together. The need for the caregiver was to ensure the child gave a proper recall. Thus far in the sample none of the children reported eating any different and/or special meals than own households. The need to adapt the tool and context has been emphasized (FAO, 2011) ii) The 12 food group is more telling and detailed than the collapsed one. Furthermore, it seems the tool is work in progress and has no international consensus on which food groups should be included when calculating scores at the individual level for different age/sex groups (FAO, 2011) and iii) It has been suggested that calculation of scores obtained from the standardized questionnaire for individuals according to the needs of the study is still appropriate.

Data collection: Respondents were asked a number of questions on which foods were consumed in the household all day the previous day until they slept. They were encouraged to include everything consumed outside the home including at school if applicable.

Serum iron and zinc status

Hypothesis: There are no significant differences in the mean serum Hb, ferritin and zinc levels when compared by season, age group and/or farming types

Variables: *Dependent*: Hb, ferritin and zinc levels *Independent*: Seasonality, age and farming type

Statistical analysis and test(s): Values for Hb, ferritin, and zinc were subjected to cut-offs by WHO (2001) according to gender. These values were exported to SPSS for further analysis using cross tabulations. Prevalence presented as % was established according to seasonality, age and farming system. Measurement of association using Pearson chi-square tests and/ or statistical significance on means using Student T-test could not be conducted on categorical variables and/or continuous data respectively because of small sample size. It has been shown that both tests can be inaccurate when expected numbers are small (Martinez-Abrain, 2014; McDonald, 2014). Similarly, no measurement of association for zinc according to seasonality, age group and/or farming system could be conducted as only one child presented with zinc deficiency. Means ± SE of parameters' concentrations were also provided.

Hypothesis testing: Mean Hb, ferritin and zinc levels were compared according to seasons, age and farming types using an Independent-Samples T-test. Significance was established at *p*-value <0.05.

Instrumentation: Tools utilized to draw blood include vacutainer with butterfly needle, alcohol swabs, cotton wool, red tops for iron and zinc storage, purple EDTA tubes for full blood count (FBC), tourniquet, safe box for disposal, sharps container for all sharp objects, permanent markers for labelling, cooler box and ice packs.

After blood was drawn, it was sent to Letsholathebe II Memorial Hospital and Gumare Primary Hospital laboratory for centrifuging by technicians.

Data collection: Data was collected using standard methods (WHO, 2010). When collecting blood, first the medical doctors explained the procedure clearly to the children giving them time for any questions and ensuring that they were comfortable about the procedure. Meanwhile all equipment was prepared in a tray next to the child. The doctor then identified a good-sized vein usually in the antecubital fossae or on the dorsum of the hand. Then the doctor applied a tourniquet proximal to the site of venipuncture to ensure engorgement of vein with blood. A vacutainer with a butterfly needle was prepared whilst the site of venepuncture was cleaned with an alcohol swab.

Finally the needle was inserted into the vein looking for blood flashback in the bevel of the syringe and approximately 10mls of blood was drawn into the tubes starting with the two red tops for iron and zinc followed by the purple EDTA tubes for full blood count. Once enough blood was drawn, the tourniquet was undone keeping the needle still in place. A cotton swab was then placed over the site of needle insertion while gently removing the needle. The child was asked to apply direct pressure with the cotton swab over the puncture to stop the bleeding.

Once the bleeding had stopped the child was asked to place the cotton wool into the safe box for disposal. Immediately the tubes were labeled with the child ID number, date, and time of sample collection, school and village to avoid mix-ups. Immediately all the samples for iron, zinc and FBC were transported to the lab in a cooler box maintaining a temperature of about 4 degrees.

Zinc samples were further centrifuged at Letsholathebe II Memorial Hospital for Shorobe samples and Gumare Primary Hospital for Tubu samples to separate the serum. Upon completion of serum separation, the serum samples were packaged and courried to National Health Lab and Diagnofirm for analysis. Samples for iron studies were kept in Letsholathebe II Memorial Hospital -80^{o}C freezer to preserve them while seeking funds to pay for the analysis.

Sample analysis at the different laboratories, namely, DiagnoFirm (zinc), National Health Lab (iron studies) and Letsholathebe II Memorial Hospital (FBC) were conducted using international standard reference methods. Serum zinc was analyzed using the liquid chromatograph mass spectrometry (CDC, 2008). Iron studies (ferritin, serum iron, transferrin, total binding capacity) were analyzed using chemiluminiscent microparticle immunoassay (Sysmex, 2011). Full blood count (white blood cells, red blood cells, hemoglobin, hematocrit, mean corpuscular volume and platelets) was analyzed using the automated hematology analyzer which used direct current detection method using the light deflection principle (Sysmex, 2011; Gundersen, 2018).

Soil Transmitted Helminth prevalence

Hypothesis: There are no significant differences in the mean intensity of infection (epg) of detected STH according to seasons, age and farming types

Variables: *Dependent*: egg per gram of detected STH *Independent*: Seasonality, age and farming type

Statistical analysis and test(s): The prevalence rate and intensity of infection (epg) were determined based on the WHO criteria (WHO, 1994). The prevalence was presented as %.

Hypothesis testing: Mean egg per gram (epg) of detected STH were compared according to seasons, age and farming types using an Independent-Samples T-test. Significance was established at p-value <0.05

Instrumentation: An active parasitological survey inclusive of a Kato Katz method for testing infection intensity (WHO, 1994) and a Formal Ether concentration method to enable picking of infection following egg concentration of intestinal parasites (WHO, 1994) were used to assess for the prevalence of STH in children. Tools used during the procedures included stool samples, sieve, flat spatula, template with hole, clean microscope slide, pre-soaked cellophane strip, sterile specimen bottle, label for child details, toilet paper, soap, water, bleach, formal ether, screw cap bottles, conical centrifuge tube, diethyl ether, tube stopper, centrifuge and cover slips.

Data Collection: An active parasitological survey was conducted whereby stool samples of children were collected and egg counts and intensity of infection were reported based on WHO criteria (WHO, 2011). Kato Kartz method was conducted to assess intensity of infestation following standard methods (WHO, 1994). The formal ether concentration technique was also used to pick infection following concentration of eggs of intestinal parasites (Kain, 2000). A health specialist familiar with the technique assisted with the analysis. The specific procedure followed is as follows:

Stool Specimen Collection

Each child was first assigned an identification number which was also written on the specimen bottle. The team leader, the health personnel in this case first reminded the children that they were going to give stool samples the size of a pea. They were then given a tissue, bottle and a wooden stick to assist with the collection of a stool sample.

The health personnel demonstrated to the children how they should carry out the procedure emphasizing the importance of submitting own samples. To ensure that there was no swapping of stool samples, assistants were placed at each toilet for observation. The children were instructed to return the samples to the station and proceed to the treatment station, whereby an assistant was present to wash children's hands with soapy water that had bleach added to it.

The children were then encouraged to rinse with running water. Once the samples were obtained the trained technician, researcher and assistants proceeded to performing the analysis on the stool samples:

Kato Kartz method: After collecting a stool sample from a child, small amounts of the faecal matter were placed on a sieve and scraped with a flat spatula across the upper surface to collect the filtered faeces. These were then added to the hole of the template so that it was completely filled. The template was then removed carefully so that the cylinder of faeces is lifted onto a clean slide. Then the faecal matter was covered with the pre-soaked cellophane strip. Using an inverted microscopic slide, the faecal sample was firmly pressed against the cellophane strip on a smooth hard surface using another slide to spread the material evenly. Then the slide was carefully removed by gently sliding it sideways to avoid separating the cellophane strip. The smear was then examined in a systematic manner with the eggs of each species reported. These were then multiplied by the appropriate number (24) to give eggs per gram of faeces. The slide for STH parasites was examined within 2 hours of slide preparation (WHO, 2011).

Formal Ether method: Using a wooden stick, a pea sized faecal matter was emulsified in about 4ml of 10% formal water (enough to cover the stool specimen) contained in a screw cap bottle. Another 4ml of 10% formal water was further added.

Then the emulsified faecal matter was sieved and the sieved suspension collected into another clean screw capped bottle and labelled accordingly. Afterwards, the suspension was then transferred to a conical centrifuge tube, where 3ml of diethyl ether was added. The tube was closed with a stopper and the mixture mixed for one minute, periodically loosening the cap. These tubes were then centrifuged immediately at 3000 revolutions per minute (Rpm) for a minute.

After centrifuging, the tube was inverted to discard the ether, faecal debris and formal water leaving behind the sediment. The tube was put back to its upright position and the fluid from the side of the tube was allowed to drain to the bottom of the tube to be re-suspended thus mixing the sediment. The sediment was then transferred to the corresponding labelled slide and covered with the cover slip. The preparation was examined under the microscope using the 10X and 40X objective with the condenser iris closed to give good contrast. A microbiology lab manual (Benson, 2002) with different pictures of parasites in slides was used for confirmation and reference. Parasites found were recorded against the specimen ID number.

Relationship between STH and iron status

Hypothesis: There is no significant difference in the mean intensity of infection (epg) of detected STH and Hb and ferritin levels when compared by seasons, age and farming types

Variables: *Dependent*: egg per gram of detected STH, Hb and ferritin levels *Independent*: Seasonality, age and farming type

Statistical analysis and test(s): For hypothesis testing, egg per gram of detected STH, Hb and ferritin levels were compared according to seasonality, age and farming type using an Independent Samples T test. Significance was established at p-value <0.05.

Instrumentation: Using SPSS software, egg per gram of detected STH, Hb and ferritin levels were used to analyze for any further relationship between the two variables. The researcher was responsible for conducting this statistical analysis.

Data Collection: Data for serum iron status was collected as for micronutrient status objective whereas for STH it was done according to the STH objective.

Household food security status

Hypothesis: There is no significant difference in the mean HFIAS scores when compared by seasons, age and farming types.

Variables: *Dependent*: HFIAS scores *Independent*: Seasonality, age and farming type

Statistical analysis and test(s): Respondent responses were entered into SPSS and coded as suggested in Coates et al, (2007) to categorize households in degrees of food security (% food (in) secure households, % of households with anxiety of food, % of households with low quality diet and % of households with food of low quality in the past 30 days). Cross tabulations were run to provide prevalence of households falling in the respective food security statuses. The HFIAS scores were calculated and reported as mean± SE.

Hypothesis testing: Mean HFIAS scores where compared according to seasons, age and farming types using an Independent-Samples T-test.

Instrumentation: A household Food Insecurity Access Scale by Coates et al, (2007) was used for the assessment of household food security status. The researcher and the CRAs administered a questionnaire face to face to caregivers over 18 years and who were responsible for the preparation of food in the household.

Data Collection: Using the HFIAS questionnaire (Coates et al, 2007), household heads and/or persons responsible over food in the households aged 18 and above were interviewed on nine food insecurity related conditions such as anxiety over food supply, insufficient food intake and quality (and frequencies) as they were experienced in the previous period of four weeks before the study data collection.

Factors of nutritional status

Hypothesis: There is no significant difference in the factors influencing nutritional status

Variables: *Dependent*: child- stunted, underweight and thin, poor child dietary diversity, household food security status, child having illness episodes vs. *Independent*: seasonality, farming type, study villages, child age, child gender, caregiver age, occupation and marital status, food groups intake (HDDS categories), whether child shares plate of food, whether harvest for the household is sufficient to last till next harvest season, household income sufficiency, availability of household food aid, child diarrhea episodes in the past month, child illness episodes in the past month, hand washing practice, household food insecurity (HFIAS score categories), harvest lasting till next harvest season, household size, caregiver attention towards the child when they are eating, use of either toilet and/or bush, having safe water supply shown by source of improved drinking water used and health care availability shown by whether child is taken to health facility when ill or no action is taken at all) were entered into the binary logistic regression model to find how factors influenced individual framework components and contribute to child's nutritional status.

Instrumentation: SPSS software was used to run the binary logistic regression to establish factors influencing nutritional status and relationship to different nutritional status indicators.

Statistical Analysis: Independent variables (predictors) as already indicated above were entered into the binary logistic regression model and tested for best of fit in explaining nutritional status represented by the dependent variable (the predicted). Since dependent variables were dichotomous and/or binary in nature and were run against multiple independent variables, it was therefore important to use binary logistic regression. Variables were coded as 1 for variable of interest and 0 for that of non-interest. Binary logistic regression has Chi Square test imbedded in. This analysis method expresses the strength of the association between a binary dependent variable and two or more independent variables using the log of the odds which are evaluated using the odds ratios. Odds ratios used in the study were expressing association between categorical dependent variable (dichotomous variables) summarized as cross tabulation and/or contingency tables (Nayaz and Hazra, 2011)

If individual predictors had Wald statistics of 0.00 in the output, then these were removed and the test was run again because it showed no effect in the influence of the dependent variable. Wald test statistic shows the effect of the individual predictors in predicting nutritional status while controlling other predictors. Thus it is informative as to whether the beta-coefficient for a certain predictor is significantly different from zero. If the coefficient is then significantly different from zero it can then be assumed that the predictor is making a significant contribution to the prediction of the outcome.

Binary logistic regression was run for all objectives except for serum iron and zinc status because of inadequate data. The last defined variable was used as a reference category. Beta (b), Wald statistic, significance, exponential beta (Exp (B) and confidence interval range were presented.

The b represented the change in the outcome for a unit change in the predictor variable. Odds ratios [Exp (B)] indicate change in odds resulting from a unit change in the predictor. If Exp (B) is > 1 it showed that odds in favor of outcome occurring increased. Contrarily if Exp (B) is < 1 it indicated that the odds in favor of the predictor decreased.

Ethical Consideration

The study was an extension of a larger project, Botswana Ecohealth Project (BEP). Permission to conduct this extension study was sought from the Ministry of Education now Ministry of Basic Education, Ministry of Health and Wellness, the Primary schools, community leaders and parents. Once permission was granted at these levels, children were requested to assent. Even if the parents gave consent and the child did not assent, the child would not be included in the study. Assenting children were asked to initial on the assent forms.

Both consent and assent were completed after a thorough verbal explanation and question and answer session so that everyone understood the importance of the study and what was requested from them. Participants were informed of their right to withdraw at any phase of the study, if they so desired.

Data management

To ensure confidentiality of information, participants' information and/or data were identified using codes known to the researcher only. Furthermore, data was stored in an external hard drive and put away in a safe location known to the researcher and a copy stored in the google drive, where access is only by invitation and is link and password protected.

Sample distribution

Figure 4 illustrates the sample distribution of the different aspects of the study according to the different seasons. The illustration showed response rates of 49.0%, 79.0%, 56.0%, 80.3% 82.0% for lean season, plenty season, iron studies work for lean season, zinc studies for lean season and zinc studies for plenty season respectively.

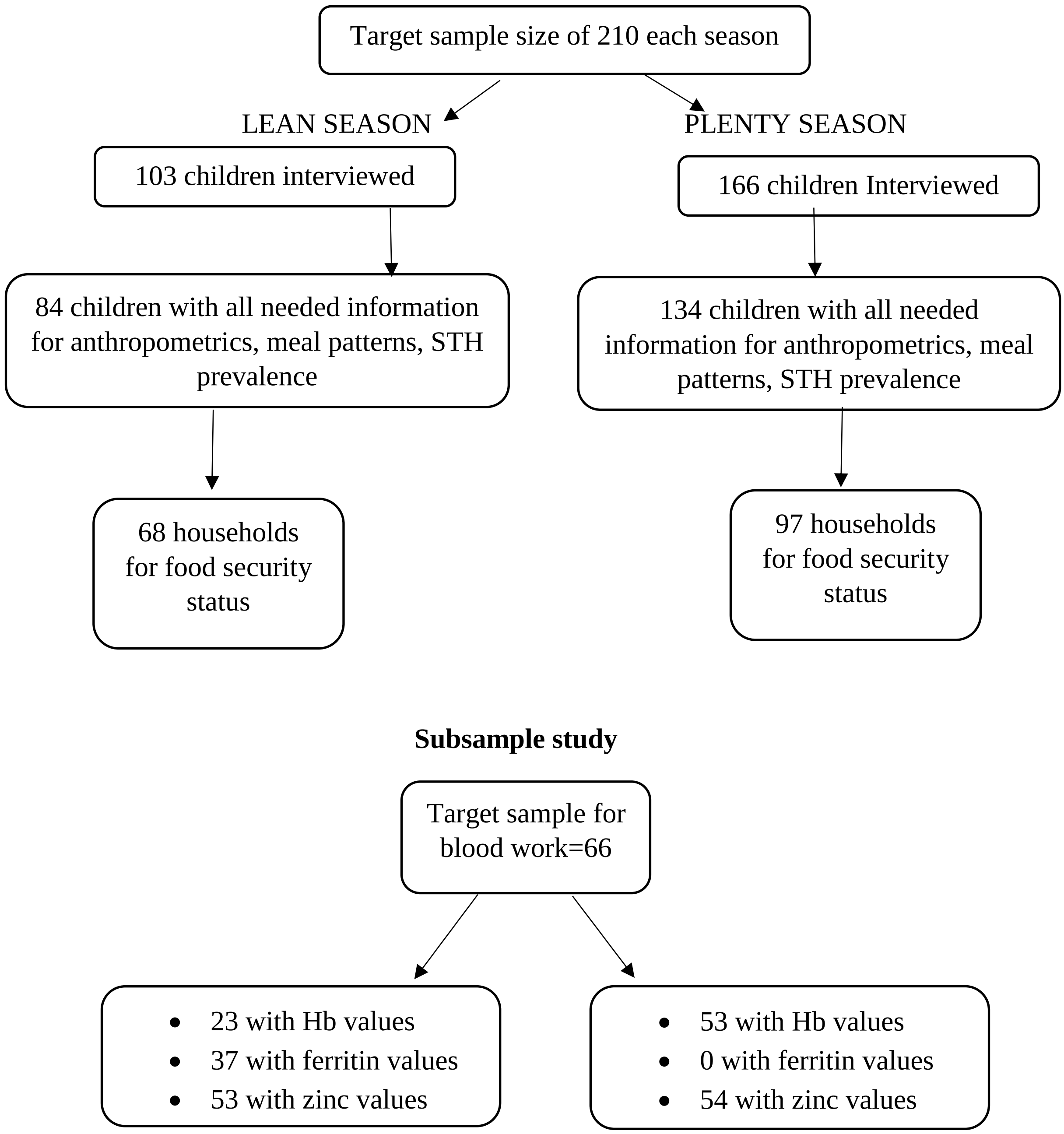

Figure 4 Sample distribution for the main study and subsample according to seasons

Operational Definitions

1. Dietary diversity: A qualitative measure of food consumption reflecting variety of foods and/or food groups (FAO, 2011). From study standpoint, the number of food groups represented in the child's diet will be analyzed. Food groups were out of a possible maximum number of 12. The higher the number the more the diverse the diet. Food groups include cereals, roots and tubers, vegetables, fruits, Meat/ poultry/ offal, eggs, fish and seafood, pulses/legumes/nuts, milk and milk products, oils/ fats, sugar/honey, miscellaneous
2. Dietary diversity score: An indicator of diet quality indicating access to a variety of foods (Swindale & Bilinsky, 2006; FAO, 2011). This is tabulated by coding each response given for the child. If the child says they have eaten the above, they are given a 1 but if not it's a 0. Thereafter, the summation of the responses is calculated. The higher the score the better the diversity (Swindale and Bilinsky, 2006) (Appendix 14). In this study, a score below 6 (<6) signified low dietary diversity and 6 and above (≥ 6) means improved dietary diversity
3. Food security: "When all people at all times have both physical and economic access to sufficient food to meet dietary needs for a productive and healthy life" (USAID, 1992)
4. Food security category: Different classes of food security status as illustrated by Coates et al, (2007) to be food secure [1], mildly food insecure [2], moderately food insecure [3] and severely food insecure [4] (Appendix 13). Due to small sample size of households, the study used two categories instead of four. These included food secure [uses food security category 1 only and as described on 6a] and the food insecure [uses food security categories 2-4 and any reported experiences as in 6b-d].

Steps to coding and assigning for the different food security categories is shown in Appendix 13.

5. Household: A unit of people living together and not necessarily related but sharing food from the same pot and answerable to the same household head (Ballard et al, 2011)

6. Household food security categories
   a. Food secure: experiences none of the food insecurity (access) conditions, or just experiences worry but rarely
   b. Mildly food insecure (access): when household worries about not having enough food sometimes or often, and/or is unable to eat preferred foods, and/or eats a more monotonous diet than desired and/or foods considered undesirable, but only rarely. However, there is no cutting back on quantity of food eaten nor does household run out of food, or members go to bed hungry or stay whole day and night without eating.
   c. Moderately food insecure: when household sacrifices quality more frequently, by eating a monotonous diet or undesirable foods sometimes or often, and/or has started to cut back on quantity by reducing the size of meals or number of meals, rarely or sometimes. But it does not experience any of the three most severe conditions
   d. Severely food insecure: household experiencing severe food insecurity conditions such as cutting back on meal size or number of meals often, and/or experiences any of the three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating), even as infrequently as rarely

7. Household food security access score (HFIAS): As suggested by Coates et al, (2007), this variable indicates the degree of food insecurity in the household. The scores are derived from the frequency of occurrence of the food insecurity conditions the household experiences. Households experiencing conditions rarely are scored 1, those having experiences sometimes (3 to <10 times) were scored 2 while those experiencing the conditions at least 10 times per month (often) are scored 3. For nine conditions, the maximum possible score is 27 (most severe food insecurity) in the past month. Illustration of the coding matrix is shown in the Household Food Insecurity Access Scale tool in the (Appendix 12)
8. Malnutrition: Malnutrition: an abnormal physiological condition, typically due to eating the wrong amount and/or kinds of foods; encompasses undernutrition and overnutrition (OW/OB) (FAO, 2013). In this study malnutrition is defined as either one of the following:

    a. Underweight (WFA-2SD≤Z): When a child's weight is lower than expected for his or her age (WHO, 2009)

        i. Severity of prevalence according to WHO (low: <10%, medium: 10-19%, high: 20-29%, very high: ≥30%)

    b. Stunting: When a child is too short for his or her age assessed by HFA Z score below -2SD (WHO, 2009)

        i. Severity of prevalence according to WHO (low:<20%, medium: 20-29%, high: 30-39%, very high: ≥ 40)

    c. Thinness (-2SD≤Z): When a child is too thin for his or her age as assessed by BMI for age Z scores below -2SD (WHO, 2009)

i. Severity of prevalence according to WHO (low: <5%, medium: 5-9%, high: 10-14%, very high: ≥15%)

d. Overweight/Obesity: When a child is too heavy for his or her age as indicated by (BMI-F-A+1SD≥Z) (WHO, 2009)

9. Iron deficiency: reduction of iron stores preceding overt IDA (Longo, 2015). Cut off:

i. Serum ferritin ≤ 12 mg/L accepted in absence of infection (WHO, 2001)

10. Iron deficiency anemia: Severe condition of low levels of iron and associated with presence of microcytic hypochromic red cells (Longo, 2015). Cut off (WHO, 2001)

a. Hb ≤115 g/dL + serum ferritin ≤ 12μg/L

i. (Boys and girls ≤11 years: Hb levels ≤11.5g/dL)

ii. Boys and girls >11 years: Hb levels ≤12.0g/dL

b. Zinc deficiency: insufficient zinc serum levels to meet body requirements resulting in clinical manifestations (Gu and Zhang, 2017)

i. (Boys and girls < 10 years: ≤ 9.9 μmol/L) (IZiNCG et al, 2004; World Health Organization/ United Nations Children's Fund/ International Energy Atomic Agency/ International Zinc Nutrition Consultative Group WHO/ UNICEF/IAEA/IZiNCG, 2007)

ii. Girl children 10 to 13 years: ≤ 10.15 μmol/L (IZiNCG et al, 2004)

iii. Body children 10 to 13 years: ≤ 10.7 μmol/L (IZiNCG et al, 2004)

11. Public health significance for anemia (No public health problem: ≤4.9%, Mild: 5-19.9%, Moderate: 20-39.9% and severe: ≥ 40%)

12. Soil transmitted helminths: Intestinal worms that infect humans and are transmitted by eggs of different species present in human faeces in contaminated soil usually and are common in poor sanitation areas (WHO, 2019).

13. Infection intensity: The mean number of parasites eggs per gram of stool in the infected host

14. STH and respective intensities are as follows:

    a. *Ancylostoma duodenal*e and *Necator americanicus* (Hookworms) infection intensity

        i. Mild infection: 1 – 1,999 epg

        ii. Moderate infection: 2,000 – 3,999 epg

        iii. Severe infection: ≥ 4,000 epg.

    b. *Ascaris lumbricoides* (Roundworms) infection intensity

        i. Mild infection: 1 – 4,999 epg

        ii. Moderate infection: 5,000 – 49,999 epg

        iii. Severe infection: ≥ 50,000 epg

    c. *Trichuris trichiura* (Whipworm) infection intensity

        i. Mild infection: 1 – 999 epg

        ii. Moderate infection: 1,000 – 9,999 epg

iii. Severe infection: ≥ 10,000 epg

15. **Seasonality**: Described according to the community seasonal calendar of events put together by participants during Participatory Rural Appraisal (PRA) meetings held at the study sites (See Appendix 1) (Botswana Ecohealth Project, 2010). The community indicated that Food is abundant usually from January to June and scarce in winter time, around July to December. Participants also pointed that around September/October there is worse shortage of food and the effects can be seen in both human beings and animals. The study therefore mirrored the calendar with data collected from November to December in what was termed pre-harvest/ post-floods and/or lean season versus May-June termed post-harvest/ pre-floods and/or plenty season.
16. Nutritional status: Individual's holistic wellbeing as assessed by anthropometric indices influenced by intake and utilization of nutrients, which is determined from information derived from physical, biochemical, clinical and dietary studies (Omage and Omuemu, 2018)

CHAPTER 4 RESULTS

Normality test results

All numeric data (weight for age Z scores, height for age Z scores, BMI for age Z scores, BMI, ferritin, hemoglobin and zinc values) for both seasons were subjected to normality tests using Shapiro-Wilk test in SPSS in order to identify if the data were normally distributed. Generally, the data were normally distributed (Appendix 2). This test of normality was chosen for its sensitivity to smaller samples between 3 and 2000. This test suggested that if after subjecting the data to normality test and the *p*-value became above 0.05, then the data are normally distributed whereas if the *p*-value was less than 0.05, then the data set was not normally distributed. Also, if testing for normality and few sets of the data proved not to be normally distributed but most were, a decision can be reached to use parametric tests and the whole data set treated as normally distributed. In subjecting the data to Shapiro-Wilk test, numerical data for all variables except BMI-for age Z scores and Hb values were normally distributed. It was expected to face such challenges because of the narrow age range of the sample coupled with small sample size. The decision reached however was to treat all data as normally distributed and to use parametric tests for statistical analysis.

Focus of the study

The study scope intended to assess nutritional status of SAC according to village, farming type, gender, age and seasonality. However, after subjecting anthropometric characteristics of SAC to statistical analysis to test for any differences, no difference in the SAC's HAZ, WAZ and BAZ were observed when compared by all the proposed variables of village, farming type, gender, age and/or seasonality (Tables 3-7).

However, since the main focus of the Botswana Ecohealth Project (BEP) and this study was on farming types and seasonality, it was decided to continue analysis by farming system and seasonality despite lack of statistical significance. For further analysis, age was included in the analysis as prompted by the literature showing that different aged school children do not respond the same way to insults in the environment and health (Medhi et al, 2006). The study focused on comparisons by farming type, age and seasonality whilst excluding analysis by village and gender.

Table 3 Mean differences in anthropometric characteristics and their significance in study children according to village

SAMPLE CHARACTERISTICS				
Anthropometric Characteristics	Village	N	Mean±SE	Sig. (2 tailed)
HAZ	Tubu	84	-0.2±0.1	*p*-value = 0.599
	Shorobe	134	-0.2±0.1	
WAZ	Tubu	42	-0.4±0.2	*p*-value = 0.084
	Shorobe	93	-0.7±0.1	
BAZ	Tubu	84	-0.7±0.1	*p*-value = 0.164
	Shorobe	134	-0.8±0.1	

*Significant at *p*-value ≤0.05

Table 4 Mean differences in anthropometric characteristics and their significance in study children according to farming type

SAMPLE CHARACTERISTICS				
Anthropometric Characteristics	Farming System	N	Mean±SE	Sig. (2 tailed)
HAZ	*Molapo*	107	-0.2±0.1	*p*-value = 0.756
	Non-molapo	111	-0.2±0.1	
WAZ	*Molapo*	60	-0.5±0.1	*p*-value = 0.576
	Non-molapo	75	-0.6±0.1	
BAZ	*Molapo*	107	-0.7±0.1	*p*-value = 0.063
	Non-molapo	111	-0.9±0.1	

*Significant at *p*-value <0.05

Table 5 Mean differences in anthropometric characteristics and their significance in study children according to gender

SAMPLE CHARACTERISTICS				
Anthropometric Characteristics	Gender	N	Mean±SE	Sig. (2 tailed)
HAZ	Females	113	-0.1±0.1	*p*-value = 0.050
	Males	105	-0.3±0.1	
WAZ	Females	71	-0.6±0.1	*p*-value = 0.913
	Males	64	-0.6±0.1	
BAZ	Females	113	-1.0±0.1	*p*-value = 0.428
	Males	105	-1.0±0.1	

*Significant at *p*-value ≤0.05

Table 6 Mean differences in anthropometric characteristics and their significance in study children according to age

SAMPLE CHARACTERISTICS				
Anthropometric Characteristics	Age	N	Mean±SE	Sig. (2 tailed)
HAZ	6-9 yrs	136	-0.2±0.1	*p*-value = 0.725
	10-13 yrs	82	-0.2±0.1	
WAZ	6-9 yrs	107	-0.7±0.1	*p*-value = 0.913
	10-13 yrs	28	-0.3±0.2	
BAZ	6-9 yrs	136	-0.7±0.1	*p*-value = 0.428
	10-13 yrs	82	-0.9±0.1	

*Significant at *p*-value ≤0.05

Table 7 Mean differences in anthropometric characteristics and their significance in study children according to season

SAMPLE CHARACTERISTICS				
Anthropometric Characteristics	Season	N	Mean±SE	Sig. (2 tailed)
HAZ	Lean	84	-0.3±0.1	*p*-value = 0.130
	Plenty	134	-0.1±0.1	
WAZ	Lean	56	-0.8±0.1	*p*-value = 0.095
	Plenty	79	-0.5±0.1	
BAZ	Lean	84	-0.9±0.1	*p*-value = 0.227
	Plenty	134	-0.7±0.1	

*Significant at *p*-value ≤0.05

Characterization of children that did not end up in the study

This section of the study gives a glimpse on the characteristics of the children who were either withdrawn by parents and/ or were excluded from the study because of incomplete questionnaires. The order of the presentation follows the general description of all the missing children per season, then those with incomplete data and comparison of means to check for statistical significant difference of the children between seasons.

Using the mean weight for age (WAZ), height for age (HAZ) and BMI for age (BAZ) of the two groups (not used in the final analysis vs used in the final analysis) in the lean and plenty seasons; t values and correspondent *p*-values were calculated. These were needed to shed light as to whether the children who did not make it to the final analysis would have made a significant difference or not if included in the study. The mean WAZ, HAZ and BAZ during the lean and plenty seasons were subjected to the following formula to find calculated t. After getting the $t_{calcuated}$, the probability of getting that t value was calculated. Using the standard normal distribution for Z tables, a number was derived that was then subtracted from 1 to give us the final *p*-value. The criteria for indicating significance was to reject the null hypothesis if *p*-value < 0.05 whereas *p*-value > 0.05 led to not rejecting of the null. Formulas used are as follows:

$$T_{calculated} = \bar{x}_A - \bar{x}_B / \sqrt{(\sigma_A^2/n_A) + (\sigma_B^2/n_B)}$$

Where $\bar{x}_A$ is the mean of group A weight/height in the respective season; $\bar{x}_B$ is the mean of group B weight/height in the respective season; σ_A^2 is variance of group A weight/height in the respective season; σ_B^2 is variance of group B weight/height in the respective season and n_A is the sample size of group A and n_B is the sample size of group B.

P-value = P [t> tcalculated].

Characteristics of the children during the lean season

During the lean season, which is when data was first collected, the target sample size was 210. However, only 103 children (49.0%) were enrolled excluding the 107 who were withdrawn at the very beginning of the study. Of these 107 children, 66 were from Shorobe and 41 were from Tubu. The majority of the group were males (n=58) when compared to females (n=49). The mean age±SE was 9.5±0.2.

Amongst the 103 children who were enrolled, only 84 had complete data. The mean age±SE was 11.0±0.2. Anthropometric characterization in terms of means for HAZ, BAZ and WAZ was -0.1±0.2, -0.8±0.3 and -0.7±0.5 respectively. None of the children were underweight or stunted. However, 3 out of 19 were thin.

Characteristics of the study children during the plenty season

Similarly, to the lean season, the target sample size was still 210. However, there was improvement in enrollment with 166 children (79.0%) interviewed. This implied withdrawal of 44 children at the beginning of the study. This pool of children comprised of 29 (65.9%) and 15 (34.1%) from Shorobe and Tubu villages respectively. There were more males (n=21, 65.6%) than females (11, 34.4%) in the group with a mean age±SE of 8.7±0.3.

Of the 166 children who were enrolled, 134 had complete data excluding 32 from analysis. The mean age±SE of the group excluded from analysis was 9.1±0.3. Anthropometric characterization in terms of means ± SE for HAZ, BAZ and WAZ was -0.5±0.2, -0.9±0.1 and -1.1±0.2 respectively. Three children were underweight, three were stunted and three were also thin.

Significance of the data not used vs used

Data used to calculate the $t_{calculated}$ were as follows. Additionally, the $t_{calculated}$ and the correspondent *p*-values for WAZ, HAZ and BAZ were included in the data to aid in decision making.

Lean season

Group A [Included in the final analysis]

Mean WAZ= -0.8; SD=1.1; N=57

Mean HAZ= -0.3; SD=1.0; N= 84

Mean BAZ= -0.9; SD=1.0; N= 84

Group B [not included in final analysis]

Mean WAZ= -0.7; SD=1.0; N=5

Mean HAZ= -0.1; SD=0.8; N= 19

Mean BAZ= -0.8; SD=1.3; N= 19

Plenty season:

Group A [Included in the final analysis]

Mean WAZ= -0.5; SD=1.0; N=79

Mean HAZ= -0.1; SD=1.1; N= 134

Mean BAZ= -0.7; SD=0.9; N= 134

Group B [not included in final analysis]:

Mean WAZ= -1.1; SD=0.8; N=22

Mean HAZ= -0.5; SD=0.9; N= 32

Mean BAZ= -0.9; SD=0.7; N= 32

Significance and decision for null hypothesis

$t_{calculatedWAZ\_L}$= -0.169; *p*-value =0.536 [Not significant]

$t_{calculatedWAZ\_P}$= 2.120; *p*-value =0.02 [Significant]

$t_{calculatedHAZ\_L}$= -0.683; *p*-value = 0.736 [Not significant]

$t_{calculatedHAZ\_P=}$ 1.575; *p*-value = 0.061 [Not significant]

$t_{calculatedBAZ\_L}$= 0.246; *p*-value = 0.600 [Not significant]

$t_{calculatedBAZ\_P}$= 0.995; *p*-value = 0.171 [Not significant]

Based on the above calculation only $t_{calculatedWAZ}$ for the plenty season was significant whereas the rest were not statistically significant in either of the seasons. The researcher therefore concluded that since almost all variables in both seasons were insignificant, a general consensus could be reached that the children excluded from the study could not have made a difference and/or changed the results currently obtained. These results therefore inform the decision to continue with the samples sizes of 84 during the lean and 134 during the plenty season.

Socio-demographic and economic characteristics of child, caregiver and household

Tables 8-10 present the study sample's socio-demographic and economic characteristics according to the child, the caregiver and the household. The characterizations were as follows:

Child socio-demographics characteristics

Age distribution showed that when study children were separated by individual age groups (6-, 7-, 8-, 9-, 10-, 11-, 12- and 13 years), all comprised of less than 30 people with some as low as three. Nonetheless, categorization by wider age groups (6 to 9 and 10 to 13 years) produced groups of more than 30 except for the 10-13 year age group in the lean which had 27 children. Categorization by wider age groups was influenced by reference standards used for zinc and iron studies (WHO, 2001; IZiNCG et al, 2004). The majority (67.9%) of the children in the lean season were younger, in the 6-9-year age group than during the plenty season (59.0%). There was an equal distribution of males and females across seasons. Generally, Shorobe village produced the most representation across season with 71.4% and 55.2% during the lean and plenty season respectively compared to 28.6% and 60% for Tubu during the lean and plenty seasons respectively. More children in the lean (41.7%) than the plenty (35.8%) season reported history of illnesses in the past month.

Furthermore, children with history of illness in the past month, most of them in the lean season (82.9%) than in the plenty season (72.9%) were taken to the clinic when ill. Also all the children in the lean season reported experiences of either bathing and/or playing in the river as compared to a few (29.1%). Fewer children in the lean season (21.4%) reported ever eating soil compared to the plenty season (29.1%). Close to 22% of the children reported practicing pica. Finally, fewer children in the lean season (41.7%) reported assisting with field work during ploughing season than in the plenty season (51.5%) [Table 8].

Table 8 Socio-demographic characterization of study children

Parameter	Lean season N=84 n [%]	Plenty season N=134 n [%]
Age distribution		
6 Years	15 [17.9]	11 [8.2]
7 Years	18 [21.4]	25 [18.7]
8 Years	15 [17.9]	19 [14.2]
9 Years	9 [10.7]	24 [17.9]
10 Years	9 [10.7]	19 [14.2]
11 Years	11 [13.1]	20 [14.9]
12 Years	7 [8.3]	13 [9.7]
13 Years	0 [0.0]	3 [2.2]
Age groups		
6 to 9 years	57 [67.9]	79 [59.0]
10 to 13 years	27 [32.1]	55 [41.0]
Gender		
Female	43 [51.2]	70 [52.2]
Male	41 [48.8]	64 [47.8]
Place of residence		
Tubu	24 [28.6]	60 [44.8]
Shorobe	60 [71.4]	74 [55.2]

Parameter	**Lean season N=84 n [%]**	**Plenty season N=134 n [%]**
History of illness in the past month		
Yes	35 [41.7]	48 [35.8]
No	49 [58.3]	86 [64.2]
Was child taken to the clinic when ill in the past month?		
Yes	29 [82.9]	35 [72.9]
No	6 [17.1]	13 [27.1]
Ever bathed and/or played in the river?		
Yes	84 [100]	39 [29.1]
No	0 [0.00]	95 [70.9]
Child ever ate soil?		
Yes	18 [21.4]	39 [29.1]
No	66 [78.6]	95 [70.9]
Child assisting in the fields during ploughing season		
Yes	35 [41.7]	69 [51.5]
No	49 [58.3]	65 [48.5]

Caregiver socio-demographic and economic characteristics

Table 9 presents the socio-demographic and economic characterization of caregivers to the study children. There was an equal distribution of the younger and older caregivers across seasons. However, there were more (almost 60%) of older caregivers in all the seasons versus the younger ones (about 40.0%). There was also an equal distribution on all the caregivers' highest education achievement categories across seasons. Few caregivers in the lean season (32.4%) lived with partners as compared to almost 40.0% in the plenty season. About 70% of caregivers in the lean season lived without partners compared to about 62.0% in the plenty season. The majority of caregivers in the plenty season (95.9%) versus 80.9% in the lean season were engaged in informal work. More children in the lean season (66.2%) were cared for by biological parents than close relatives (33.8%) when compared with the plenty season where 55.7% and 44.3% of the children were cared for by biological parents and close relatives respectively.

Table 9 Socio-demographic and economic characterization of caregivers

Parameter	Lean season N=68 n [%]	Plenty season N=97 n [%]
Caregiver age group		
≤34 years	28 [41.2]	39 [40.2]
≥35 years	40 [58.8]	58 [59.8]
Caregiver's highest educational achievement		
None	14 [20.6]	22 [22.7]
Primary	24 [35.3]	31 [32.0]
Secondary (including Tertiary)	30 [44.1]	44 [45.4]
Caregiver marital status		
Living with partner	22 [32.4]	37 [38.1]
Living without partner	46 [67.6]	60 [61.9]
Caregiver occupation		
Formal	13 [19.1]	4 [4.1]
Informal	55 [80.9]	93 [95.9]
Caregiver relation to child		
Biological parent	45 [66.2]	54 [55.7]
Others (close relatives)	23 [33.8]	43 [44.3]

Household characteristics

Table 10 indicates characterization of study households. There was an equal distribution of households with ≤4 members and ≥5 members across seasons. However, generally households were larger across all seasons with ≥5 members (close to 90.0%) than ≤4 members (about 12.0%). There was an increased representation of *molapo* households in the plenty season (51.5%) than the lean season (44.1%). Thus a higher representation of non-*molapo* households was observed in the lean (55.9%) than the plenty season (48.5%). There was an equal distribution of households in both seasons (no more than 16.5%) reporting inadequacy of previous harvests in sustaining them till the next harvesting season.

More households in the plenty (21.6%) reported inadequate household income than in the lean season (10.3%). Consequently, the plenty season had more households (22.7%) receiving food aid than in the lean season (17.6%). There was almost an equal distribution of households of younger (17.5%) and older (17.9%) aged caregivers reporting having received food aid in the past 3 months in the lean season. However, in the plenty season many caregivers older (27.6%) than younger (15.4%) reported having received help with food and/or food ration in the past three months. Majority of households in the lean season (64.7%) did not own a toilet as compared to 55.7% in the plenty season. There was an equal distribution of households with improved sources (taps, boreholes, and protected dug well), non-improved sources (river and or unprotected hand dug well) and/or both (improved and non-improved sources) of water across seasons at estimates of about 93%, 1.5% and 6% respectively.

Table 10 Study household characterization

Parameter	Lean season N=68 n [%]	Plenty season N=97 n [%]
Household size		
≤4 members	7 [10.3]	12 (12.4]
≥5 members	61 [89.7]	85 [87.6]
Type of farming households		
Molapo	30 [44.1]	50 [51.5]
Non-molapo	38 [55.9]	47 [48.5]
Household adequacy of previous harvest until next harvest		
Yes	11 [16.2]	16 [16.5]
No	57 [83.8]	81 [83.5]
Perceived adequacy of household income		
Yes	7 [10.3]	21 [21.6]
No	61 [89.7]	76 [78.4]
Households receiving food aid		
Yes	12 [17.6]	22 [22.7]
No	56 [82.4]	75 [77.3]
Households receiving aid by age		
≤34 years	5 [17.9]	6 [15.4]
≥35 years	7 [17.5]	16 [27.6]

Parameter	Lean season N=68 n [%]	Plenty season N=97 n [%]
Household ownership of toilet		
Yes	24 [35.3]	43 [44.3]
No	44 [64.7]	54 [55.7]
Source of drinking water		
Improved (tap/ borehole, protected dug well and rainwater)	63 [92.6]	90 [92.8]
Non improved (river/stream/hand & unprotected dug well)	1 [1.5]	1 [1.0]
Both	4 [5.9]	6 [6.2]

Anthropometric status of children (6 to 13 years)

Figure 5 presents observations that the levels of underweight (12.3% and 6.3%), stunting (6.0% and 5.2%), thinness (11.9% and 7.4%) and OW/OB (4.8% and 4.4%) were higher during the lean season than during the plenty season respectively.

In summary, undernourishment presenting as underweight (12.3%) and thinness (11.9%) were more prevalent in the lean season and had almost doubled as compared to what they were during the plenty (6.3% and 7.4% respectively) season. The seasonal variations in underweight and thinness seem to be consistent with the expected variations of protein energy intake between seasons. There was still a factor of the double burden of malnutrition observed as indicated by stunting (6% and 5.2%) and overweight/obesity (4.8% and 4.4%) prevalence almost similar for the lean and plenty seasons respectively.

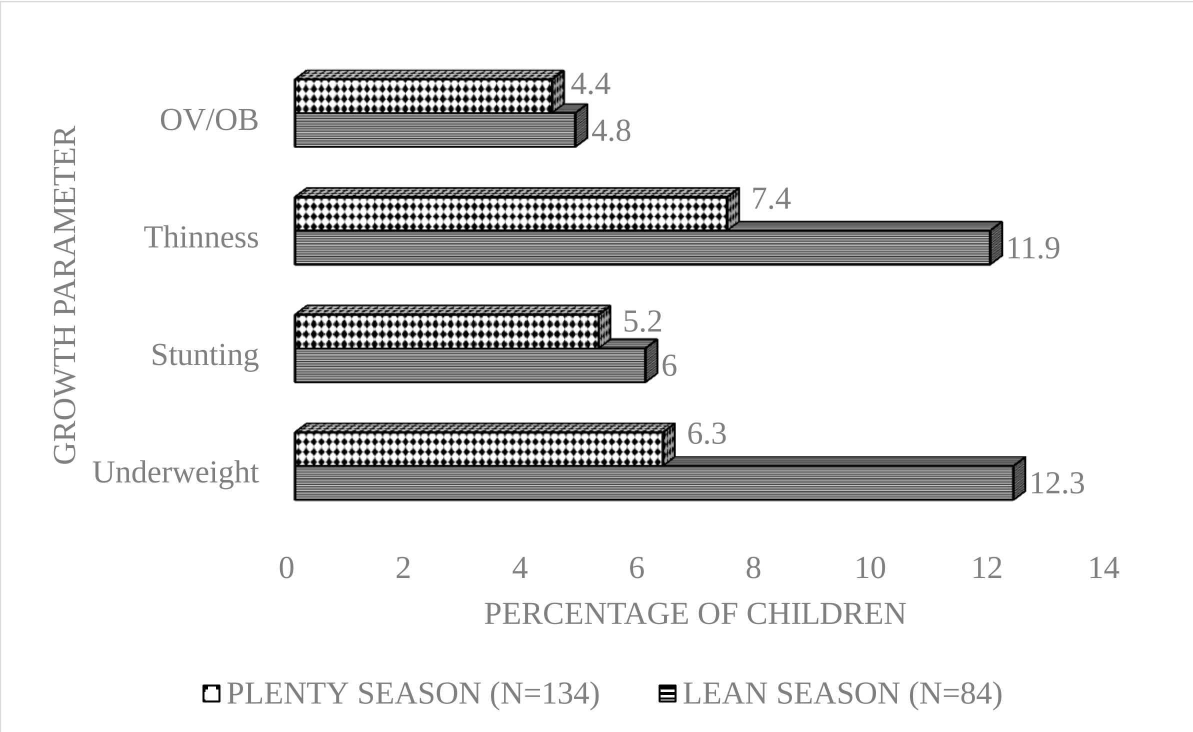

Figure 5 Growth status of study children according to season

It was noticed in Figure 6 that the older age group (10 to 13 years) of children were more likely to be thin irrespective of season compared to the younger age group (6 to 9 years). For instance, 9.1% of them were thin compared with 5.1% of the 6-9 year olds in the plenty season. The same trend was observed with OW/OB in the plenty season, 5.5% of the 10-13 year olds experienced OW/OB in the plenty season against 2.5% of the 6-9 year olds.

However, underweight was predominantly among the 6-9 year olds in all seasons (6.3% in the plenty and 10.5% in the lean). Stunting was more visible among the younger age group (6 to 9 years). For example, during the plenty season, 5.1% were stunted against 3.6% for the 10 to 13 year olds.

In summary, both undernutrition (stunting, underweight, thinness) and overnutrition (OW/OB) were observed in the study children irrespective of season and age. However, the younger children tended to be more undernourished than overnourished in both seasons whereas the older children were thinner during the lean season.

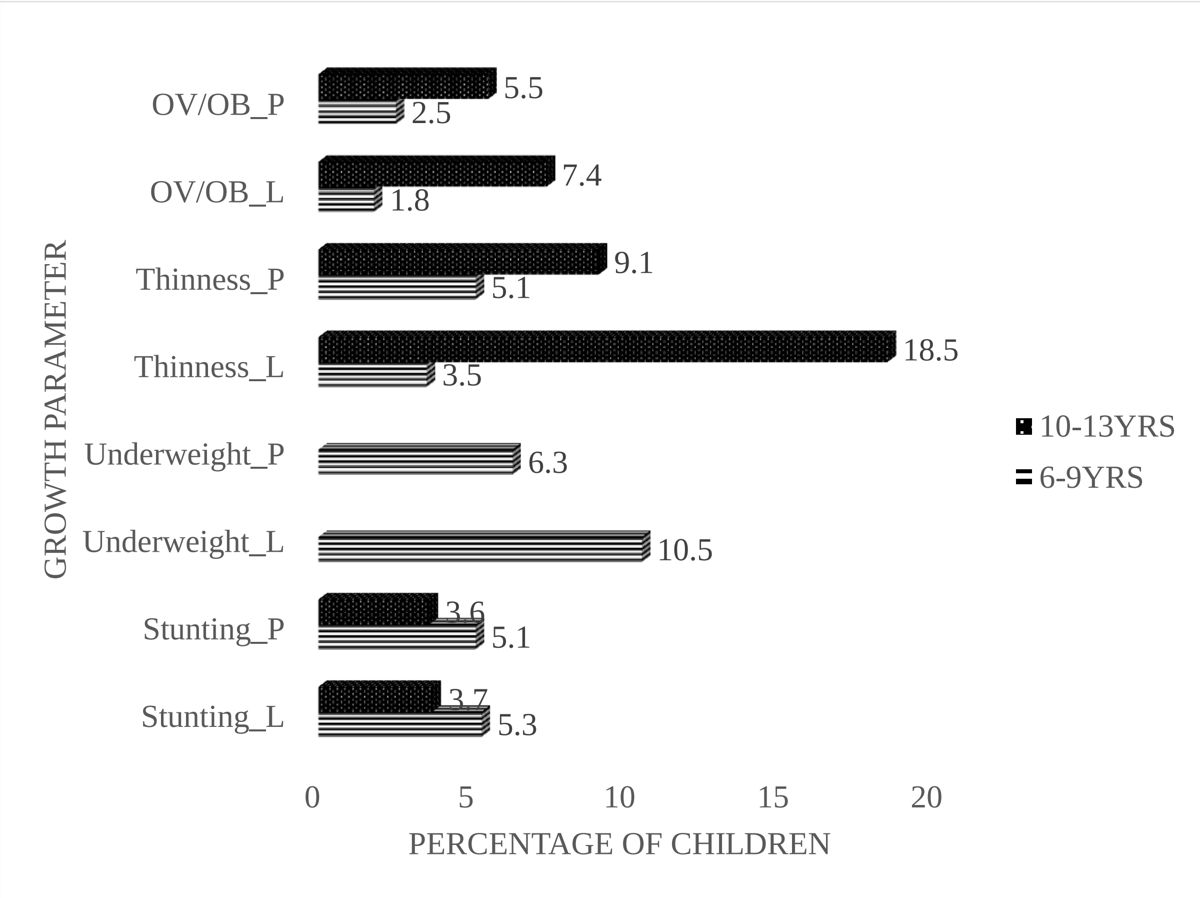

Figure 6 Growth status of study children according to age

Figure 7 displays the prevalence of stunting, underweight, thinness and OW/OB according to farming type. In the lean season, children from *molapo* farming households experienced less undernutrition as indicated by stunting, underweight and thinness prevalence at no more than 6% each and as compared to children in *non-molapo* households. Similarly, OW/OB was at par with thinness at 5.7% in *molapo* farming children in the lean season.

In comparison, children from *non-molapo* farming households during the lean season suffered more from undernutrition with pronounced prevalence for underweight and thinness at 15.2% and 10.2% respectively followed by stunting at 6.1%. Overweight and obesity was almost non-existent at 2%. Generally, *molapo* farming households seemed better off nutritionally in both season as compared to *non-molapo* farming children.

In summary, undernutrition in the form of stunting, underweight and thinness was less common in the lean season for *molapo* farming children and more common for those residing in *non-molapo* farming households. However, in the plenty season, a change was observed with *molapo* farming children experiencing more undernutrition and OW/OB and *non-molapo* farming children experiencing a decrease in all growth parameters.

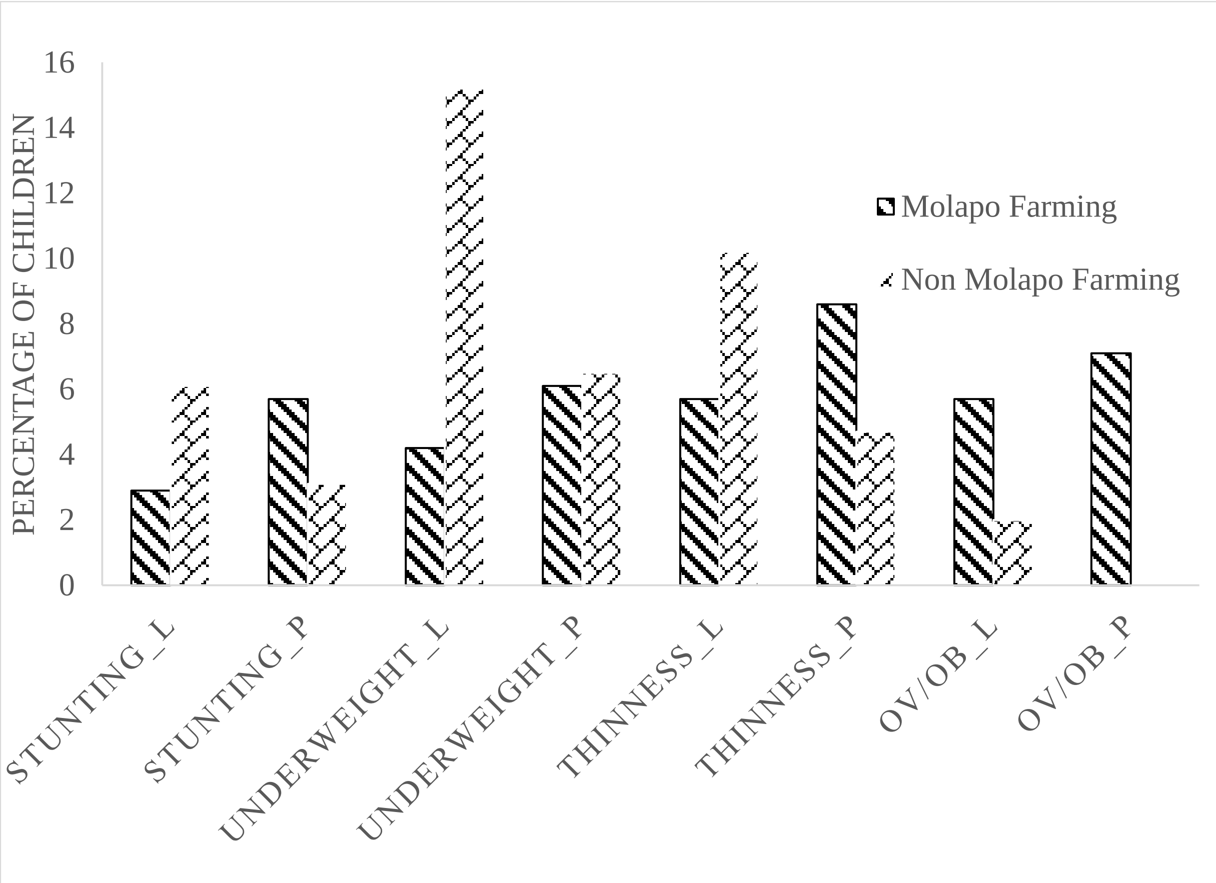

Figure 7 Growth status of study children according to farming type

Hypothesis 1: There are no significant differences in the WAZ, HAZ and BAZ means according to seasons, farming types and age.

Table 11 indicates the mean HAZ and corresponding significance according to season. There was no statistical significant difference in the seasonal mean HAZ (lean: -0.4±0.1 and plenty: -0.2±0.1, t (213) = -1.547, p>0.05). The null hypothesis was therefore not rejected thus confirming that there was no statistical significant difference between the mean HAZ and consequently stunting in children when compared by season.

Table 11 Mean HAZ and significance according to seasons

Growth Parameter	Season	N	Mean	SE	Mean Difference	T	DF	Sig (2) tailed
HAZ	Lean	83	-0.373	0.1	-0.220	-1.547	213	0.123
	Plenty	132	-0.153	0.1				

*Statistical significance at p<0.05

Table 12 presents the mean HAZ and corresponding significance according to age group in the respective seasons. There was no statistical significant difference in the mean HAZ of the different age groups in both seasons (lean: 6 to 9 years: -0.4±0.1 and 10 to 13 years: -0.3±0.2, t (81) = -0.461, p>0.05) and (plenty: 6 to 9 years: -0.2±0.1 and 10 to 13 years: -0.2±0.1, t (128) = 0.104, p>0.05). The null hypothesis was therefore not rejected thus confirming that there was no statistical significant difference between the mean HAZ and consequently stunting of children in all age groups across both seasons.

Table 12 Mean HAZ and significance according to age

Growth Parameter	**Season**	**Age group**	**N**	**Mean**	**SE**	**Mean Difference**	**T**	**DF**	**Sig (2) tailed**
HAZ	Lean	6-9 yrs.	56	-0.407	0.1	-0.106	-0.461	81	0.646
		10-13yrs	27	-0.301	0.2				
	Plenty	6-9 yrs.	75	-0.182	0.1	0.185	0.104	128	0.918
		10-13yrs	55	-0.200	0.1				

*Statistical significance at $p<0.05$

Table 13 presented observations on the mean HAZ and corresponding significance according to farming type in the respective seasons. Similarly, to seasonality and age group, there was no statistical significant difference in the mean HAZ of the children from the different farming types in either the lean and/or plenty seasons respectively (*lean*: *molapo*: -0.3±0.2 and *non-molapo*: -0.4±0.1, t (81) = 0.423, p>0.05) and (*plenty*: *molapo*: -0.2±0.1 and *non-molapo*: -0.02±0.1, t (132) = -0.955, p>0.05). Similarly, the null hypothesis was not rejected thus confirming that there was no statistical significant difference in the mean HAZ and consequently stunting of children when comparing by farming types in the two seasons.

Table 13 Mean HAZ and significance according to farming type

Growth Parameter	**Season**	**Age group**	**N**	**Mean**	**SE**	**Mean Difference**	**T**	**DF**	**Sig (2) tailed**
HAZ	Lean	*Molapo*	34	-0.318	0.2	0.092	0.423	81	0.674
		N. Molapo	49	-0.410	0.1				
	Plenty	*Molapo*	70	-0.200	0.1	-0.178	-0.955	132	0.342
		N. Molapo	64	-0.023	0.1				

*Statistical significance at p<0.05

Factors influencing stunting, underweight and thinness in study children

Table 14 indicate factors that influenced stunting in study children. Of all factors entered in the binary regression, none of the factors were found to be significant (p<0.05) in influencing stunting.

Table 14 Factors influencing stunting

Variable contribution to stunting	Reference	ß	Sig.	Exp (ß)	95% C.I for Exp (ß)	
					Lower	Upper
Seasonality	Plenty vs. **Lean season**	-0.185	0.794	0.831	0.207	3.336
Child illness episodes in past month	No vs. **Yes**	0.425	0.550	1.530	0.380	6.168
Dietary diversity (food group intake)	<6 food groups vs. **≥6 food groups**	-0.422	0.578	0.656	0.149	2.893
Child sharing a plate of food	No vs. **Yes**	0.201	0.778	1.223	0.303	4.942
Child gender	Male vs. **Female**	2.321	0.029	10.181	1.260	82.242

*significance at p<0.05; Dependent variable: Child being stunted; bolded means reference used to interpret likelihood of event happening

Underweight

Table 15 indicates the mean WAZ and corresponding significance level according to season. There was a statistically significant difference in the seasonal mean WAZ (lean: -0.8±0.1 and plenty: -0.5±0.1, t (133) = -2.144, p<0.05). The null hypothesis was therefore rejected thus confirming that there was a statistically significant difference between the mean WAZ and consequently underweight of study children when compared by season. Thus children were likely to be underweight during the plenty season.

Table 15 Mean WAZ and significance according to seasons

Growth Parameter	Season	N	Mean	SE	Mean Difference	T	DF	Sig (2) tailed
WAZ	Lean	56	-0.841	0.1	-0.370	-2.144	133	0.034*
	Plenty	79	-0.470	0.1				

*Statistical significance at p<0.05

Mean WAZ and significance according to age group

Mean WAZ and corresponding significance according to age group in the respective seasons could not be established. This is because the underweight indicator is relevant only to children less than 10 years. There was therefore no comparison group to carry out this analysis.

Mean WAZ and significance according to farming type

Table 16 displays the mean WAZ and corresponding significance according to farming type in the respective seasons. There was no statistical significant difference in the mean WAZ of the children in the different farming types in either the lean and/or plenty seasons respectively (lean: *molapo*: -0.7±0.2 and *non-molapo*: -0.8±0.2, t (55) = 0.508, p>0.05) and (plenty: *molapo*: -0.6±0.2 and *non-molapo*: -0.5±0.1, t (76) = -0.331, p>0.05). The null hypothesis was not rejected thus confirming that there was no statistical significant difference in the mean WAZ and consequently underweight of children when comparing by farming types.

Table 16 Mean WAZ and significance according to farming type

Growth Parameter	Season	Farming type	N	Mean	SE	Mean Difference	T	DF	Sig (2) tailed
WAZ	Lean	*Molapo*	24	-0.681	0.2	0.147	0.508	55	0.614
		N. Molapo	33	-0.828	0.2				
	Plenty	*Molapo*	32	-0.560	0.2	-0.073	-0.331	76	0.742
		N. Molapo	46	-0.487	0.1				

*Statistical significance at p<0.05

Factors influencing underweight

Table 17 indicates factors that influenced underweight in study children. Similarly to stunting, none of the factors entered into the binary regression were found to be significant (p<0.05) in the influence of underweight.

Table 17 Factors influencing underweight

Variable contribution to underweight	**Reference**	**ß**	**Sig.**	**Exp (ß)**	**95% C.I for Exp (ß)**	
					Lower	**Upper**
Seasonality	Plenty vs. **Lean season**	-0.697	0.365	0.498	0.110	2.247
Child illness episodes in past month	No vs. **Yes**	1.986	0.067	7.289	0.870	61.063
Dietary diversity (food group intake)	<6 food groups vs. **≥6 food groups**	0.073	0.923	1.075	0.246	4.706
Child sharing a plate of food	No vs. **Yes**	0.647	0.438	1.910	0.372	9.804

*significance at $p<0.05$; Dependent variable: Child being underweight; bolded means reference used to interpret likelihood of event happening

Thinness

Table 18 presents the mean BAZ and corresponding significance according to season. There was no statistical significant difference in the seasonal mean BAZ (lean: -1.0 ±0.1 and plenty: -0.8±0.1, t (208) = -1.502, p>0.05). The null hypothesis was not rejected thus confirming that there was no statistical significant difference between the mean BAZ and consequently thinness of children when compared by season.

Table 18 Mean BAZ and significance according to seasons

Growth Parameter	Season	N	Mean	SE	Mean Difference	T	DF	Sig (2) tailed
Thinness (BAZ<-2 SD)	Lean	81	-0.985	0.1	-0.171	-1.502	208	0.135
	Plenty	129	-0.813	0.1				

*Statistical significance at $p<0.05$

Table 19 displays the mean BAZ and corresponding significance according to age group in the respective seasons. There was no statistical significant difference in the mean BAZ of the different age grouped children in the lean (*lean*: 6 to 9 years: -0.9±0.1 and 10 to 13 years: -1.2±0.2, t (79) = 1.541, p>0.05) as compared to the plenty season (*plenty*: 6 to 9 years: -0.7±0.1 and 10 to 13 years: -1.0±0.1, t (127) = 0.104, p<0.05). The null hypothesis for the lean season was therefore not rejected thus confirming lack of statistical significance in the mean BAZ and consequently thinness of children across all age groups in the lean season. However, the null hypothesis was rejected for the plenty season thus confirming a statistically significant difference in BAZ and/or consequent thinness in children across age groups in the plenty season.Thus younger children aged 6 to 13 years were likely to be thin especially during the plenty season.

Table 19 Mean BAZ and significance according to age

Growth Parameter	Season	Age group	N	Mean	SE	Mean Difference	T	DF	Sig (2) tailed
BAZ	Lean	6-9 yrs.	56	-0.886	0.1	0.320	1.541	79	0.127
		10-13yr	25	-1.206	0.2				
	Plenty	6-9 yrs.	77	-0.705	0.1	0.269	1.988	127	0.049*
		10-13yr	52	-0.974	0.1				

*Statistical significance at $p<0.05$

Table 20 presents the mean BAZ and corresponding significance according to farming type in the respective seasons. There was no statistical significant difference in the mean BAZ of the children in the different farming types in either the lean and/or plenty seasons respectively (*lean*: *molapo*: -0.8±0.1 and *non-molapo*: -1.1±0.1, t (79) = 1.505, p>0.05) and (*plenty*: *molapo*: -0.8±0.1 and *non-molapo*: -0.8±0.1, t (127) = -0.487, p>0.05). The null hypothesis was not rejected thus confirming lack of statistical significant difference in the mean BAZ and/or consequently thinness of children when compared by farming types in both seasons.

Table 20 Mean BAZ and significance according to farming type

Growth Parameter	**Season**	**Farming Type**	**N**	**Mean**	**SE**	**Mean Difference**	**T**	**DF**	**Sig (2) tailed**
BAZ	Lean	*Molapo*	33	-0.811	0.1	0.294	1.505	79	0.136
		N. Molapo	48	-1.105	0.1				
	Plenty	*Molapo*	65	-0.846	0.1	-0.066	-0.487	127	0.627
		N. Molapo	64	-0.780	0.1				

*Statistical significance at p<0.05

Factors influencing thinness

Displayed in table 21 are factors that may potentially influence thinness in study children. One factor being child age was statistically significant in influencing thinness. Child age was also positively associated with thinness. This meant that with each one year increase in age, children 6 to 9 years were 3.079 times more likely to become thin. Other factors were not statistically significant in predicting the likelihood of child thinness.

In summary, none of the factors entered into the binary regression seemed to have any influence in stunting and underweight. However, only one factor being child age (6 to 9 year age range) seemed to influence vulnerability to thinness by 8%.

Table 21 Factors influencing thinness

Variable contribution to thinness	Reference	ß	Sig.	Exp (ß)	95% C.I for Exp (ß)	
					Lower	Upper
Child age	10 to 13 years vs. **6 to 9 years**	1.125	0.041*	3.079	1.045	9.071
Seasonality	Plenty season vs. **Lean season**	-0.300	0.608	0.741	0.235	2.333
Child illness episodes in past month	No vs. **Yes**	0.519	0.395	1.681	0.507	5.570
Dietary diversity (food group intake)	≥6 food groups vs. **<6 food groups**	0.598	0.295	1.818	0.594	5.566
Child sharing a plate of food	No vs. **Yes**	-0.705	0.195	0.494	0.170	1.435

*significance at p<0.05; Dependent variable: Child being thin; bolded means reference used to interpret likelihood of event happening

BAZ ≥1 and significance according to season, age and farming type

Significance of differences on OW/OB could not be established due to a small number of children (n=8) falling in this category.

In summary, statistically significant differences were observed when comparing underweight by seasonality and thinness by age groups. On average children were more likely to be underweight in the plenty season whereas younger children (6 to 9 years) were more likely to be thin.

Meal patterns

By season

Figure 8 displays meal patterns by seasons for the study children. This is indicated by representation of food groups in the diets as reported from intake of the past 24 hours to the day of interview. Generally, more households in the lean than in the plenty season consumed more food groups. The top 6 consumed food groups amongst the children during the lean season included cereals (96.4%), miscellaneous (condiments, coffee, tea or beverages at 90.5%), sugar/honey (86.9%), meat/poultry/offal (73.8%), oils/fats (71.4%) and milk and milk products (52.4%). The rest of the food groups were consumed by less than 23% of children in the lean season. In comparison, the top 6 most consumed food groups during the plenty season included cereals (91.0%), sugar/honey (84.3), miscellaneous (78.4%), meat/poultry/offal (61.2%), milk and milk products (60.4%) and oils and fats (38.1%). The rest of the food groups such as roots and tubers, vegetables, fruits, eggs, fish and seafood and pulses/legumes/nuts were consumed by less than 15% of children. There was a statistically significant difference observed between the food group intakes of the seasons (Table 22).

In summary, the bulk of the children's diets comprised of starchy foods with some protein rich foods in both seasons. Though eating patterns are almost similar in both seasons, the consumption of energy dense foods seemed higher in the lean season than plenty season.

Contrarily, consumption of healthy foods which could be easily procured whether through purchasing, picking as farm produce and or gathering from the wild) was lower in the plenty season than the lean season. Examples of nutrient rich foods could have included fish, *mophane worm*, bean leaves, pumpkins, wild fruits such as *mogwana* (baobarb fruit) and *mokolwane* (palm fruit), *tswii* (water lily) and mushrooms.

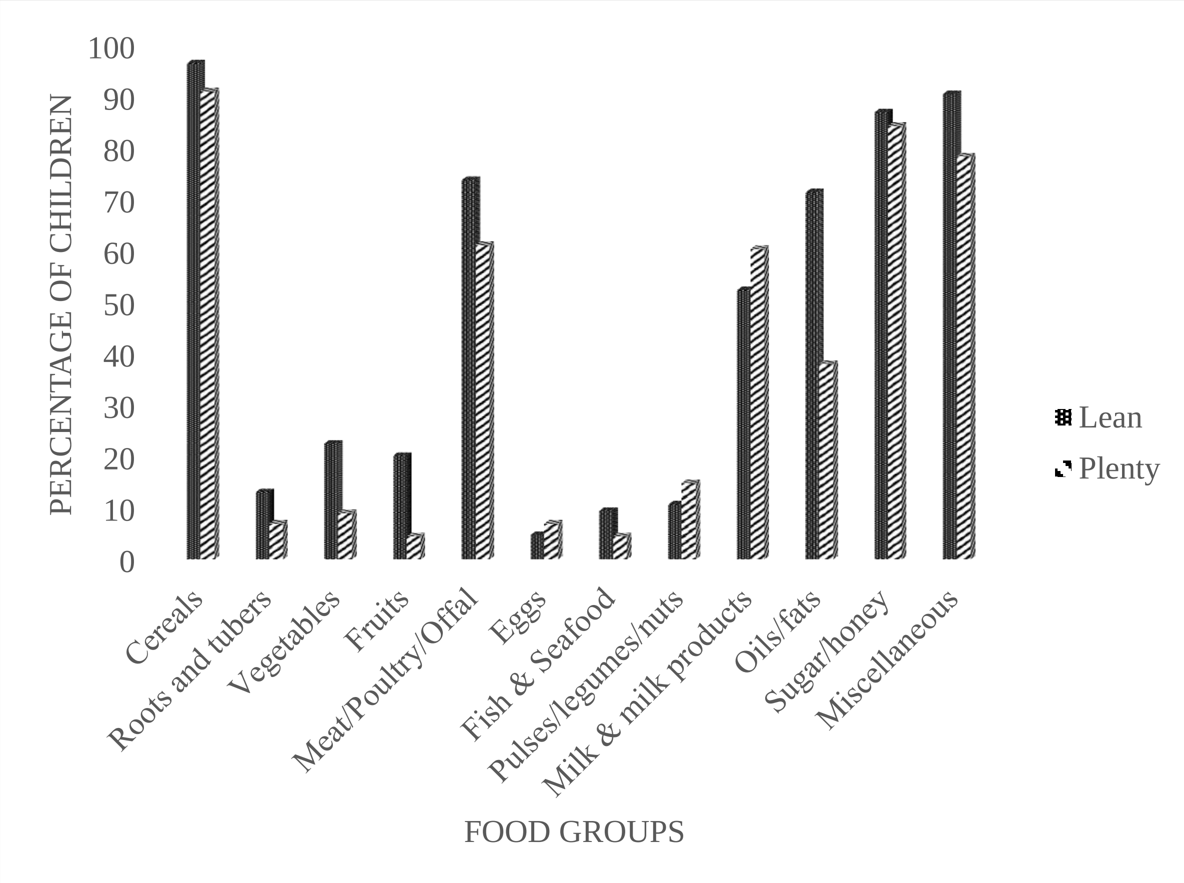

Figure 8 Food group representation in children's diets in the previous day of consumption according to season

Meal patterns by age in the lean and plenty seasons respectively

Figure 9 and 10 illustrates the children's meal patterns by assessing food group representation in the diets in the past 24 hours according to age in the different seasons. In all the seasons, both the younger and the older children seemed to consume the same food groups. However, more children reported eating these food groups in the lean season than in the plenty season. No statistical significant difference was observed in the food group intake of the younger and/or the older children in any of the seasons (Table 23). Diets of younger children (6 to 9 years) in the lean season comprised of cereals (96.5%), miscellaneous (91.2%), sugar/honey (86.0%), meat/poultry/offal (70.2%), oils/fats (68.4%) and milk and milk products (52.6%).

The rest of the food groups were consumed by less than 27% of the children. Older children (10 to 13 years)'s intake was also similar with cereals (89.9%), sugar/honey (88.9%), miscellaneous (88.9%), meat/poultry/offal (81.5%), oils/fats (77.8%) and milk and milk products (51.9%). Other food groups such as roots and tubers, vegetables, fruits, eggs, fish and seafood and pulses/legumes/nuts were consumed by less than 15% of the children.

In the plenty season, younger children still consumed cereals (89.9%), sugar (89.9%), miscellaneous (79.7%), meat/poultry/offal (64.6%), milk and milk products (60.8%), and oils and fats (36.7%) with the rest of the food groups being eaten by no more than 13%. The older children's diet also included cereals (92.7%), sugar/honey (76.4%), miscellaneous (76.4%), milk and milk products (60.0%), meat/poultry/offal (56.4%) and oils/fats (40.0%). The remaining food groups were consumed by no more than 8% of the children.

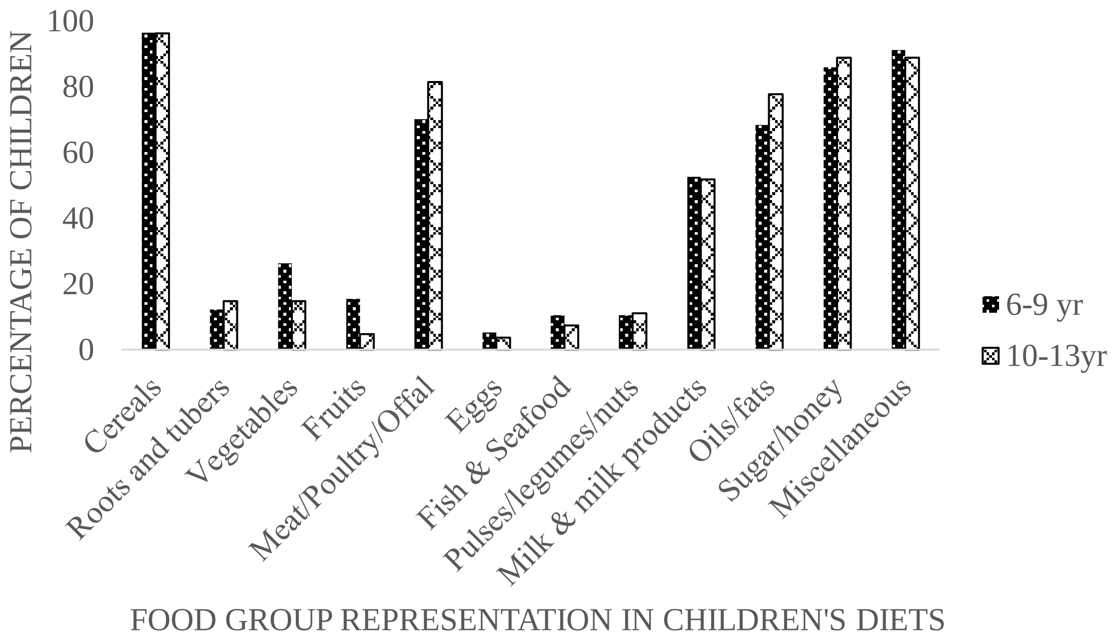

Figure 9 Food group representation in children's diets according to age in the lean season

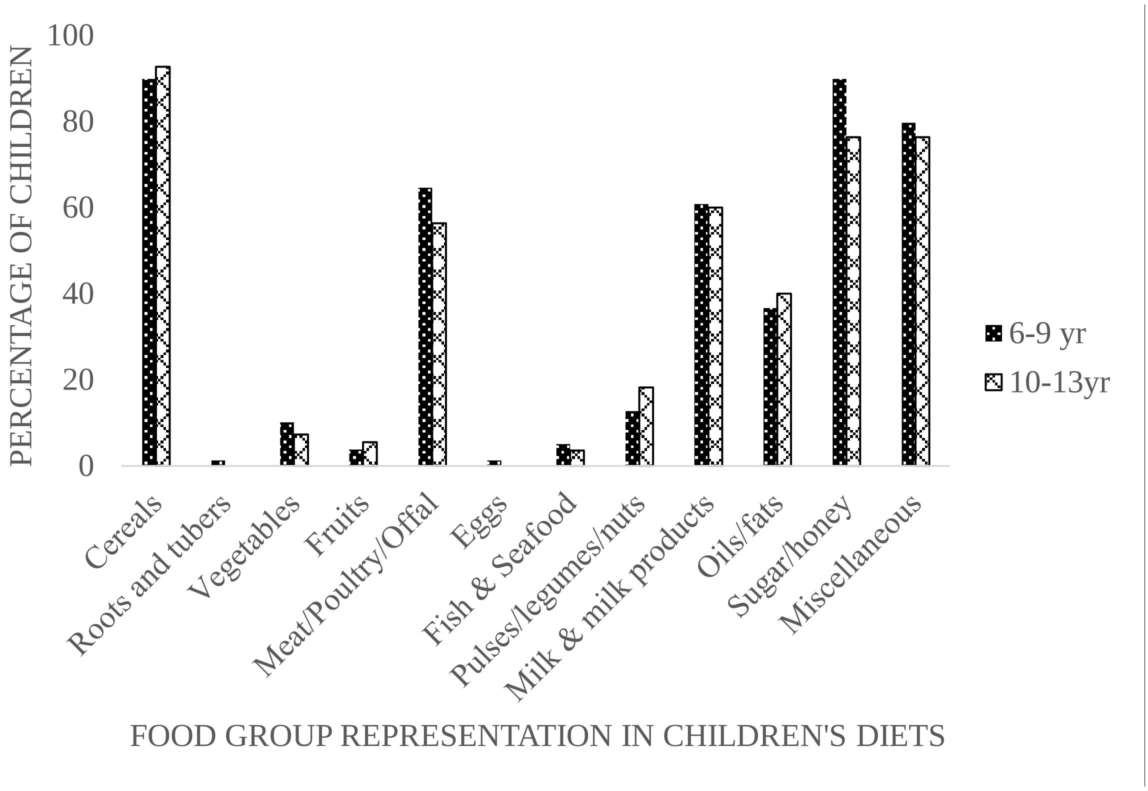

Figure 10 Food group representation in children's diets according tto age in the plenty season

In summary, regardless of age, the children's diets were predominately cereals, miscellaneous food staffs (condiments, beverages such as tea and coffee), sugar/honey, meat/poultry/offal, oils/fats and milk and milk products. There is almost an equal distribution of food groups between the younger and older age groups in the lean season. It is in the lean season where it seemed as though most children consumed protein rich foods (6-9 year: meat/poultry/offal=70.2%; 10-13 year: 81.5%) compared to plenty season (6-9 year: meat/poultry/offal=64.6%; 10-13 year: 56.4%). Nutrient dense foods such as roots and tubers, vegetables, fruits, eggs, fish and seafood and pulses/legumes/nuts seemed to be out of reach for most of the children as representation in all seasons was observed in no more than 27% of the children. More specifically, only the younger children in the lean season were fed with these nutrient dense foods and the older age group in the plenty season were the least represented in the consumption of these nutrient dense food groups.

Meal patterns by farming types in the lean and plenty season respectively

Figures 11 and 12 indicate food group representation in children's diets according to farming types in the different seasons. Generally, it was observed that the number of food group (n=6) intake was similar among farming types in all seasons. However, it seemed that there were more children eating these food groups (cereals, miscellaneous, sugar/honey, oils/fats, meat/poultry/offal and milk and milk products) in *non-molapo* children than *molapo* children. Furthermore, intake of the above food groups was more common in the lean (Figure 11) than plenty (Figure 12) season. There was a statistically significant difference observed in the food group intake between the farming systems only during the plenty season but not the lean season (Table 24). Another observation although with a small percentage of children (no more than 23%), showed that more *molapo* farming children consumed roots and tubers, fish and seafood and pulses and legumes in both seasons compared to non molapo children.

The makeup of *molapo* farming children's diets during the lean season (Figure 11) included cereals (94.3), sugar/honey (85.6%), miscellaneous (82.9%), oils/fats (62. 9%), meat/poultry/offal (60.0%) and milk and milk products (57.1%). The remaining food groups were consumed by no more than 20% of the children. In comparison in the lean season, *non-molapo* farming children consumed cereals (98.0%), miscellaneous (95.9%), sugar/honey (87.8%), meat/poultry/offal (83.7%), oils/fats (77.6%) and milk and milk products (49.0%). Roots and tubers, vegetables, fruits, eggs, fish and seafood and pulses/legumes/nuts were consumed by no more than 26%.

During the plenty season (Figure 12), most of the children's diets in *molapo* farming consisted of cereals (91.4%), sugar/honey (78.6%), miscellaneous (75.5%), milk and milk products (60.0%), meat/poultry/offal (50/0%) and oils/fats (28.6%). Less than 24% of the children consumed the remaining food groups.

On the other hand, the children from *non-molapo* farming households consumed mostly cereals (90.6%), sugar/honey (90.6%), miscellaneous (81.3%), meat/poultry/offal (73.4%), milk and milk products (60.9%) and oils/fats (48.4%). Roots and tubers, vegetables, fruits, eggs, fish and seafood and pulses/legumes/nuts were represented in no more than 12% of the children's diets.

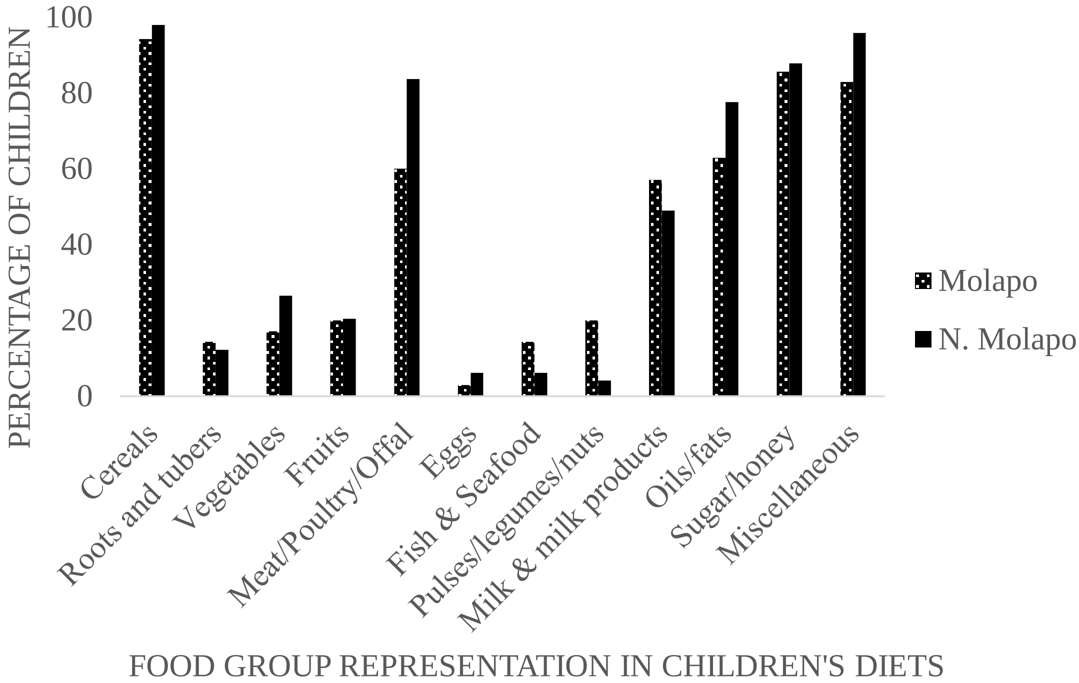

Figure 11 Food group representation in the children's diets in the past 24 hours of consumption by farming type in the lean season

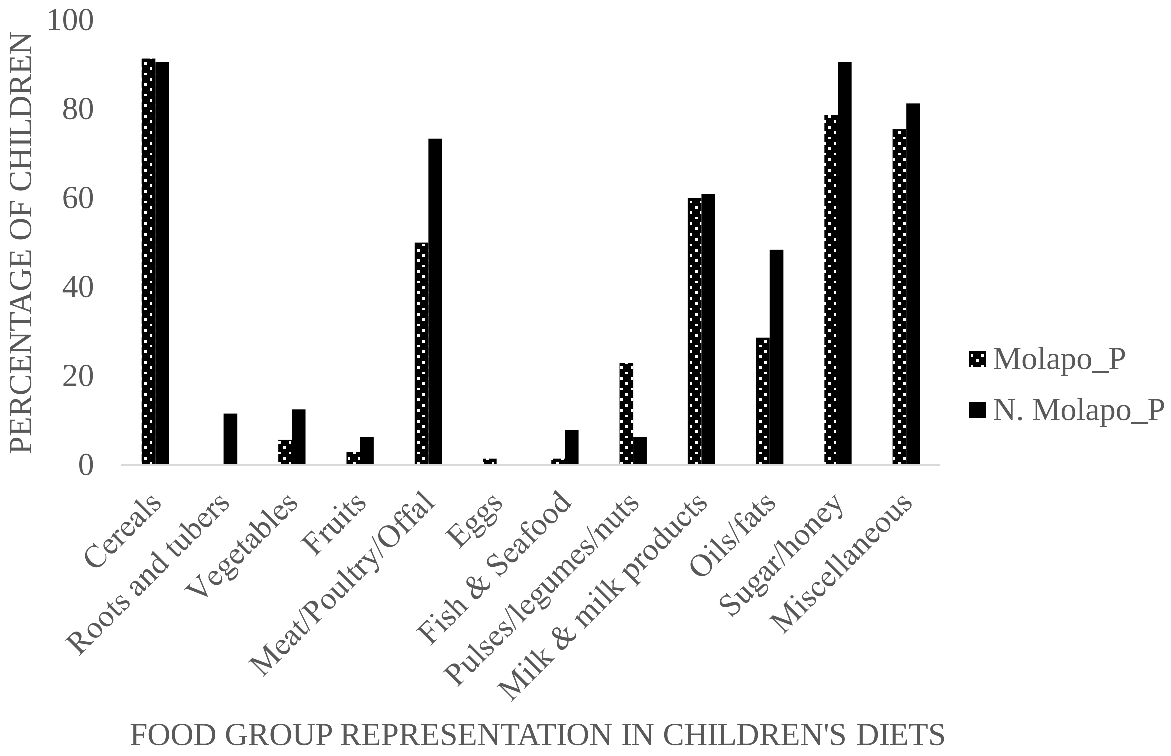

Figure 12 Food group representation in the children's diets in the past 24 hours of consumption by farming type in the plenty season

In summary, all the children from both farming types had diets largely made of six food groups namely cereals, sugar/honey, miscellaneous food staffs, meat/poultry/offal, oils/fats and milk and milk products. Overall no more than 26% of all children irrespective of farming system had representation of roots and tubers, vegetables, fruits, eggs, fish and seafood and pulses/legumes/nuts in the diets. Additionally, consumption of energy dense foods and protein rich foods were more represented in the diets of children from *non-molapo* farming than *molapo* farming children’s diets. Thus there seemed to be a slight improvement in the dietary diversity of the diets of *non-molapo* farming children compared to those of *molapo* faming children.

Hypothesis 2: There are no significant differences in the mean HDDS when compared by seasons, age and farming types

Table 22 indicates the mean HDDS and corresponding significance according to season. There was a statistically significant difference observed in the seasonal mean HDDS (lean: 5.5 ± 0.2 and plenty: 4.5 ± 0.1, t (216) = 4.450, p<0.05). The null hypothesis was rejected thus confirming that there was a statistically significant difference between the mean HDDS and consequently dietary diversity of children across seasons. Using the mean HDDS, it is shown that on average, dietary diversity was better off in the lean than the plenty season.

Table 22 Mean HDDS and significance according to season

Dietary Parameter	Season	N	Mean	SE	Mean Difference	T	DF	Sig (2) tailed
HDDS	Lean	84	5.524	0.2	1.046	4.450	216	0.000
	Plenty	134	4.478	0.1				

Table 23 presents the mean HDDS and corresponding significance according to age groups in the respective seasons. There was no statistical significant difference in the mean HDDS observed in the age groups in the different seasons (*lean*: 6 to 9 years: 5.5±0.2 and 10 to 13 years: 5.5±0.4, t (82) = 0.018, p>0.05) as compared to the plenty season (*plenty*: 6 to 9 years: 4.6±0.2 and 10 to 13 years: 4.4±0.2, t (132) = 0.692, p>0.05). The null hypothesis is therefore not rejected thus confirming lack of statistical significant difference in the children’s mean HDDS and consequently dietary diversity when compared by age in the different seasons.

Table 23 Mean HDDS and significance according to age

Dietary Parameter	Season	Age group	N	Mean	SE	Mean Difference	T	DF	Sig (2) tailed
HDDS	Lean	6-9 yrs	57	5.526	0.2	0.008	0.018	82	0.986
		10-13 yrs	27	5.519	0.4				
	Plenty	6-9 yrs	79	4.557	0.2	0.193	0.692	132	0.490
		10-13 yrs	55	4.364	0.2				

*Significant at p<0.05

Table 24 presents the mean HDDS and corresponding significance according to farming type in the respective seasons. There was no statistical significant difference in the mean HDDS of the children in the different farming types in the lean seasons (*lean*: *molapo*: 5.3±0.4 and *non-molapo*: 5.7±0.2, t (82) = -0.881, p>0.05). The null hypothesis was not rejected for the lean season confirming lack of statistical significant difference in the mean HDDS and/or consequently dietary diversity of children when compared by farming types. On the contrary, a statistically significant difference was observed in the plenty season (*plenty*: *molapo*: 4.2±0.2 and *non-molapo*: 4.8±0.2, t (132) = -2.248, p<0.05). The null hypothesis for the plenty season was therefore rejected thus confirming a statistically significant difference in the mean HDDS and/or consequent dietary diversity of children when compared by farming types.

Table 24 Mean HDDS and significance according to age

Dietary Parameter	Season	Farming Type	N	Mean	SE	Mean Difference	T	DF	Sig (2) tailed
HDDS	Lean	*Molapo*	35	5.314	0.4	-0.359	-0.881	82	0.381
		N. Molapo	49	5.674	0.2				
	Plenty	*Molapo*	70	4.186	0.2	-0.611	-2.248	132	0.026*
		N. Molapo	64	4.797	0.2				

*Significant at $p<0.05$

Factors affecting meal patterns (dietary diversity)

Table 25 displayed factors that may influence meal patterns of study children. Four factors were statistically significant in their influence towards child dietary diversity or food group intake (reference variable: consumption of 6 and/or more food group). These factors included household income, seasonality (plenty), farming system (molapo) and study village (Tubu). Of these four, three being household income, plenty season and Tubu village were negatively associated with the children's dietary diversity whereas one being molapo farming system, was positively associated with the children's dietary diversity.

Household income reduced children's dietary diversity. For every unit increase in household income, the child's dietary diversity was likely to reduce by 0.112 units. Thus the likelihood of the child consuming 6 or more food groups when a household has adequate income was rather reduced by 11%.

Similarly, seasonality also seemed to have a negative influence on child dietary diversity. Thus with every additional plenty season, child dietary diversity worsened by 0.092 units. This meant that with every plenty season, a child's chances of eating 6 or more food groups reduced by 9%. It was also observed from the results that a child associated with Tubu was 0.102 times less likely to consume 6 and/or more food groups implying compromised dietary diversity by 10%.

On the contrary, a child related to *molapo* farming, increased dietary diversity by 9.444 units. This meant that a child from *molapo* farming was likely to consume 6 and or more food groups by 44% compared to counterparts. The rest of the factors were not statistically significant towards influencing child dietary diversity.

Table 25 Factors influencing Child meal patterns

Variable contribution to poor meal patterns (poor dietary diversity)	**Reference:**	**ß**	**Sig.**	**Exp (ß)**	**95% C.I for Exp (ß)**	
					Lower	**Upper**
Food security status	Food insecure vs. **Food secure**	-0.651	0.221	0.521	0.184	1.480
Harvest lasting till next harvest	Harvest didn't last vs. **Harvest lasted**	0.320	0.499	1.377	0.544	3.485
Caregiver age	≤34 vs. **≥35 years**	-0.563	0.216	0.570	0.233	1.390
Caregiver marital status	Living without vs. **Living with partner**	-0.143	0.735	0.867	0.380	1.980

Variable contribution to poor meal patterns (poor dietary diversity)	**Reference:**	**ß**	**Sig.**	**Exp (ß)**	**95% C.I for Exp (ß)**	
					Lower	**Upper**
Caregiver occupation	Informal vs. **Formal employment**	1.183	0.102	3.263	0.789	13.484
Caregiver education	No education vs. **Some education**	-0.733	0.178	0.480	0.165	1.396
Household income sufficiency	No vs. **Yes**	-2.186	0.000*	0.112	0.035	0.364
Caregiver presence at mealtime	No vs. **Yes**	0.511	0.249	1.667	0.700	3.974
Seasonality	Plenty vs. **Lean Season**	-2.383	0.000*	0.092	0.038	0.226
Farming Type	*Non-Molapo* vs. ***Molapo***	2.245	0.008*	9.444	1.797	49.621
Village	Shorobe vs. **Tubu**	-2.284	0.010*	0.102	0.018	0.575
Having received Food Aid in past 3 months	No vs. **Yes**	0.144	0.785	1.155	0.411	3.250
Household size	≥5 vs. **≤4 members**	0.158	0.810	1.171	0.323	4.252

*significance at $p<0.05$; Dependent variable: Child dietary diversity; bolded means reference used to interpret likelihood of event happening

Serum iron and zinc status

Iron status

Anemia by season

Iron status was assessed amongst study children. Iron status was categorized into three levels, being anemia illustrated by Hb levels ≤115g/L, ID shown by Ferritin levels ≤12ug/L in the absence of infection checked by fever temperature over 36 degrees celsius and IDA indicated by Hb levels ≤115g/L combined with Ferritin levels ≤12ug/L. None of the girl children had reached menarche stage at the time of data collection in both seasons.

The results indicate that the mean±SE for ferritin and hemoglobin in the lean season were 51.0±4.1 ug/L and 119.0±0.4 g/L respectively. In comparison, the mean±SE for hemoglobin in the plenty season was 121.0±0.2 g/L. The range for ferritin levels in the lean season was 13.8 to 104.8 ug/L. The range for hemoglobin levels in the lean and plenty seasons were 51.0 to 145.0 g/L and 92.0 to 144.0 g/L respectively.

It was further shown that 4 of 23 (17.4%) and 18 of 53 (33.9%) had anemia in the lean and plenty season respectively. There were no children with ID and/or IDA in the lean season. Prevalence for ID and IDA could not be established in the plenty season due to loss of blood samples between Letsholathebe II Memorial Hospital and the National Health Laboratory.

Anemia by age group

During the lean season, 23 blood sample results were available. Of these samples, 17 (73.9%) were under 11 years of age and 6 (26.1%) were over 11 years. The results further indicated that there was an equal distribution of anemia amongst the different age groups of the children during lean season. Overall, 4 children out of 23 presented with anemia. Within these 4 children, two were below 11 years and two were above 11 years of age.

During the plenty season 53 blood samples were available. About 45 children (84.9%) were in the younger age category of less than 11 years whereas 8 (15.1%) were in the older age category of over 11 years. About 18 out of 53 (34.0%) children had anemia. Of these, 18 children, 13 (72.2%) and 5 (27.8%) were below 11 years and above 11 years respectively. In summary, it seemed as though younger children were anemic than the older ones.

Anemia by farming type

During the lean season, 23 blood samples were analysed for anemia. There were 8 (34.8%) and 15 (65.2%) children from *molapo* and *non-molapo* farming households respectively. About 4 presented with anemia during the lean season. Of these four, three and one were from *molapo* and *non-molapo* farming households respectively.

In comparison, 53 samples were analysed during the plenty season and 29 (54.7%) and 24 (45.3%) were from *molapo* and *non-molapo* farming households. Of these 53, 18 (34.0) presented with anemia. From the 18, 10 (34.5%) and 8 (33.3%) resided in *molapo* and *non-molapo* farming households.

In summary, anemia seemed to be more common in the plenty season than the lean season. Two children below 11 years and two above 11 years were anaemic in the lean season whereas in the plenty season an increased number of younger children were affected.

Comparison by farming types showed more children in *molapo* than *non molapo* households being anaemic in both seasons.

Statistical significant differences could not be established for ID and IDA across seasons, age and/or farming type due to insufficient data for use in the comparison. Similarly, statistical difference could not be established for anemia (Hb values) across seasons, age and farming types due to small numbers of children presenting with anemia.

Zinc status

Serum zinc analysis was conducted for 36 children in the lean season and 54 in the plenty season. References used were gender and age specific thus requiring zinc deficiency analysis to be done in three parts, namely for boys and girls less than 10 years at ≤ 9.9umol/L, for girls 10 to 13 years at ≤10.15 µmol/L and for boys 10 to 13 years at ≤10.7 µmol/L. The mean±SE for zinc in the lean and plenty seasons were 12.7±0.3 µmol/L and 20.9±0.5 µmol/L respectively. The zinc levels for the lean and plenty season respectively were 8.1 to 15.8 µmol/L and 13.3 to 27.90 µmol/L respectively. Only one girl child at 6 years of age from a *molapo* farming household presented with zinc deficiency of 8.10 umol/L in the lean season.

Thereafter, none of the children in the plenty season were zinc deficient. Statistical difference could not be established as well due to only one child presenting with zinc deficiency.

Anemia is becoming a health concern amongst the children although statistical significance could not be established. In contrast, zinc deficiency is not a health concern amongst children, with only one child at the age of 6 years presenting with levels below 9.9umol/L of 8.10 umol/L. A flow chart (Figure 13) simplifying the results follow:

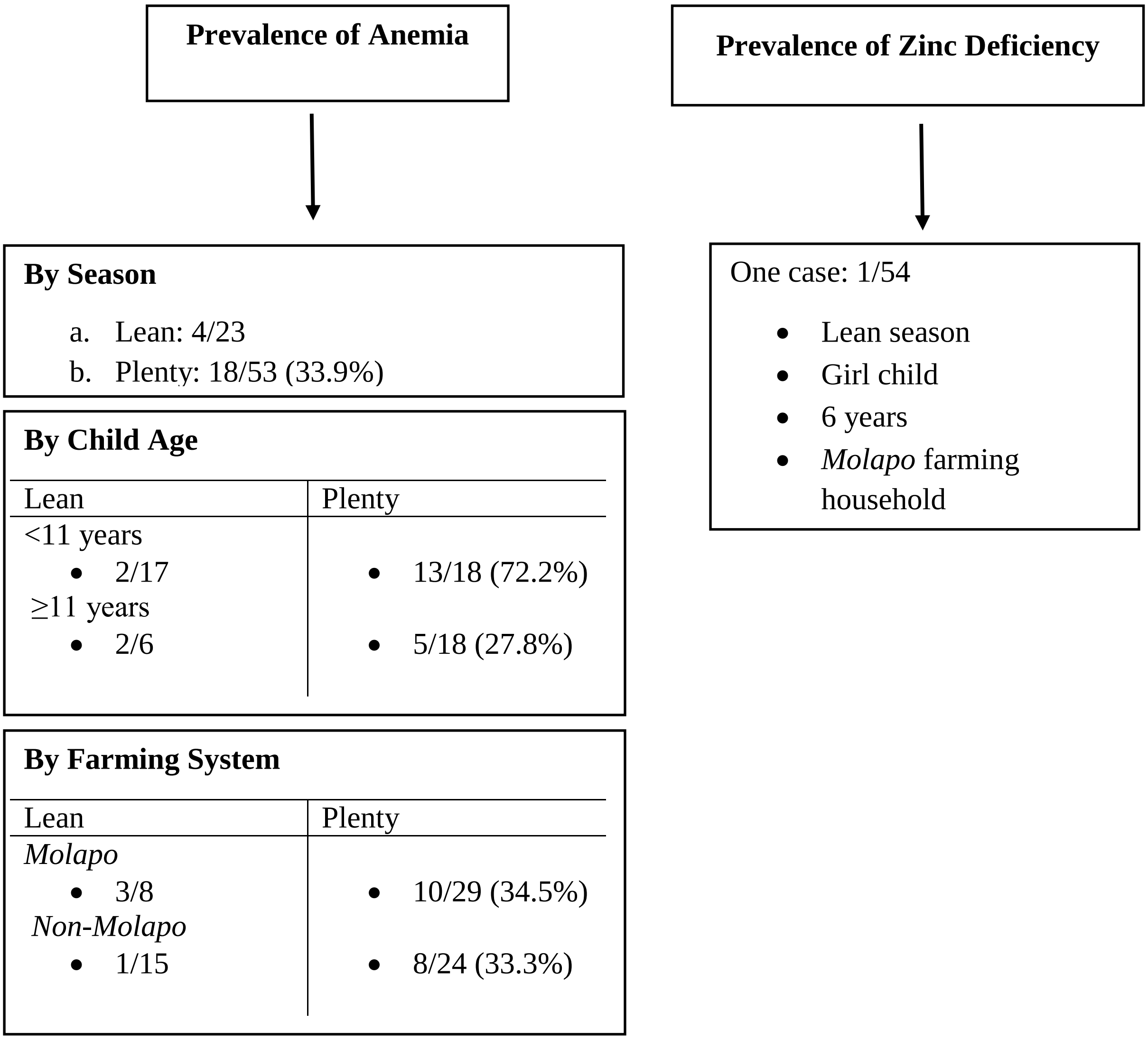

Figure 13 Flowchard displaying prevalence of anemia and zinc deficiency in study children

Prevalence of soil transmitted helminthes in children (6 to 13 years)

Parasitic infestation during lean season

None of the children presented with soil transmitted helminthes. However, other intestinal parasites were found. For instance, six out of 84 (7.1%) children presented with other parasitic infestations during lean season. From the six children, four and two presented with H. diminuta and H nana respectively.

Parasitic infestation during plenty season

Investigations showed that only one girl child aged 9 years from a *non-molapo* farming household in Shorobe village during the plenty season presented with an STH specifically, *Ancyclostoma duodenale* hookworm. The intensity of the infection was low with number of eggs per gram of 69, which illustrated a light infection. Significance with STH between season, age group and/or farming system could not be established as only one child presented with STH.

Other intestinal parasites

Of prominence in children were other intestinal parasites rather than soil transmitted ones during the plenty season. For instance, 15 (11.2%) of the children presented with other types of intestinal helminthes. These included *H. diminuta*, *H. Nana* and *D. Latum* at 5.2%, 4.5% and 1.5% respectively. More children in plenty than lean season presented with intestinal parasites other than STH.

Hypothesis testing for STH prevalence and establishment of the relationship between iron status and STH prevalence could not be established due to insufficient data. Since there was insufficient data to address serum iron and zinc, STH and relationship of iron and STH objectives, factors influencing these could not be established.

Household food security status

Figure 14 displays the situation of household food security in the farming households where the study children lived.

It was observed that more (95.6%) households during the lean season than the plenty (88.7%) were food insecure. Only a small proportion in both seasons (4.4% in lean and 11.3% in plenty) were food secure.

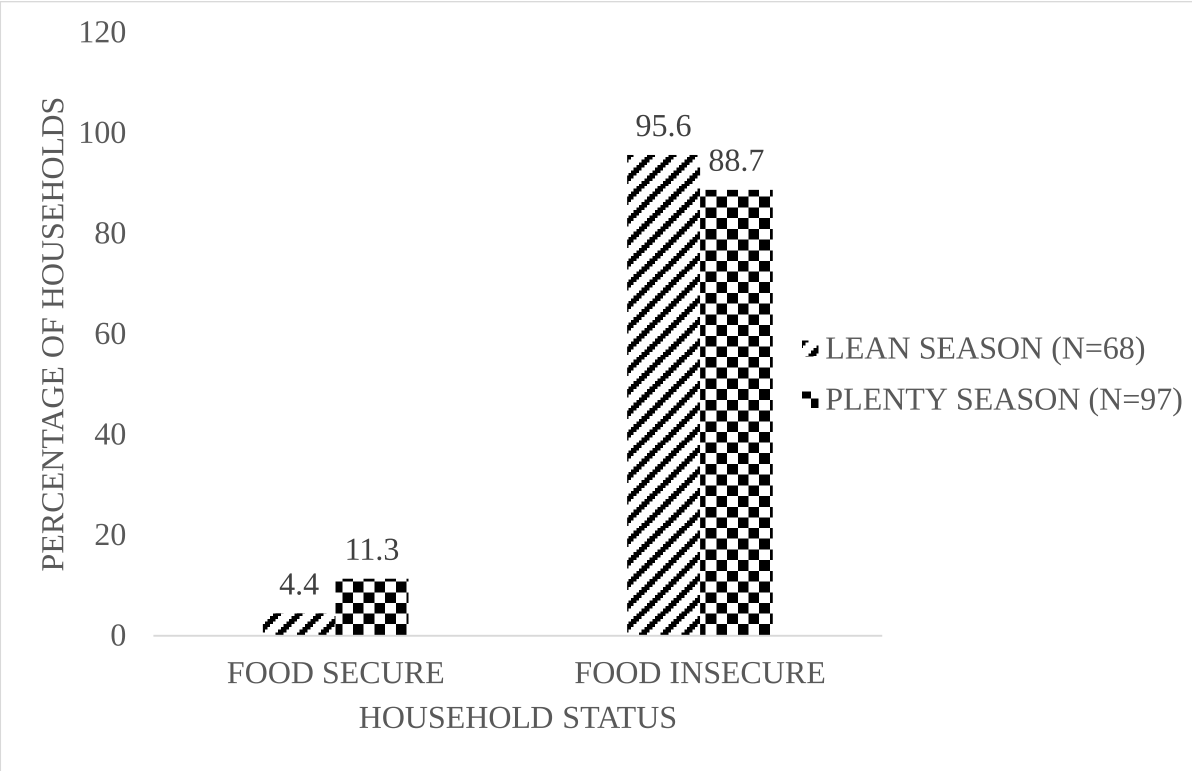

Figure 14 Household food insecurity status in study areas according to seasons

Table 26 expounds on the food security status where the study children lived by closely examining accessibility of food in respective households in the past 30 days according to season. It was noticed that household food insecurity was a major concern for households in both seasons but more so in the lean that in the plenty season. Food insecurity in these households proved severe as shown by the drastic reactions and responses that over 50% of households irrespective of season took.

Over the past month, 67% of households had been worried about their inadequate food supply. Households had to compromise on the quality of food they consumed as shown by >75.0%, >71.0% and >67.0% reporting inability to consume kinds of foods they liked, eating limited variety of foods than desired and eating food not wanted respectively.

The severity of food insecurity was observed from the extent to which the households compromised food intake. Households reported eating smaller meals than desired (>72.0%) and eating fewer meals per day than desired (>67.0%). The worst reported scenarios included having some members of the households going to sleep hungry (>42.0%) and even going the whole day and night without food (>23.0%).

In summary, households in both seasons experienced food insecurity as observed by their increased worry over the inadequacy of household food supply, intake of food of compromised quality and poor intake of food in general. Additionally, it was evident that households faced more struggles in the lean season than in the plenty season. However, observing the frequency of occurrence of food insecurity experiences, households in the plenty season sometimes (3-10 times) and often (>10 times) reported going a day and night without food as compared to the lean season. Food insecurity domains that often occurred included consumption of food of insufficient quality (24.7% - 48.5%), insufficient quantity (6.2% - 33.4%) and anxiety over household food supply (20.6% - 22.1%) in the respective order.

Table 26 Household food insecurity conditions and frequency of occurrence as experienced in the past month according to seasons

Food Insecurity Domains & Conditions experienced by Households		N [%] of Households			
		Seasonal Households Affirmation	**Occurred rarely 1-2X**	**Occurred Sometimes 3-10X**	**Occurred Often > 10 X**
Anxiety and uncertainty of food supply	Worry that food is not enough	Lean: 52 [76.5] Plenty: 65 [67.0]	27 [39.7] 19 [19.6]	10 [14.7] 26 [26.8]	15 [22.1] 20 [20.6]
Insufficient Food quality	Unable to eat kinds of food liked	Lean: 58 [85.3] Plenty: 73 [75.3]	18 [26.5] 19 [19.6]	12 [17.6] 27 [27.8]	28 [41.2] 27 [27.8]
	Ate limited variety of foods than desired	Lean: 54 [79.4] Plenty: 69 [71.1]	11 [16.2) 15 [15.5]	7 [10.3] 23 [23.7]	33 [48.5] 31 [32.0]
	Ate food not wanted	Lean: 50 [73.5] Plenty: 65 [67.0]	15 [22.1] 19 [19.6]	10 [14.7] 22 [22.7]	23 [33.8] 24 [24.7]
Insufficient food intake	Ever ate smaller meals than desired	Lean: 55 [80.9] Plenty: 70 [72.2]	21 [30.9] 15 [15.5]	16 [23.5] 32 [33.0]	18 [26.5] 23 [23.7]
	Fewer meals per day than desired	Lean: 53 [77.9] Plenty: 65 [67.0]	17 [25.0] 13 [13.4]	14 [20.6] 30 [30.9]	22 [32.4] 22 [22.7]
	Had no food of any kind	Lean: 38 [55.9] Plenty: 40 [41.2]	17 [25.0] 12 [12.4]	11 [16.2] 20 [20.6]	9 [13.2] 8 [8.2]
	Ever slept hungry in the past 30 days	Lean: 38 [55.9] Plenty: 41 [42.3]	14 [20.6] 16 [16.5]	17 [25.0] 12 [12.4]	7 [10.3] 13 [13.4]
	Ever went the whole day and night without food	Lean: 18 [26.5] Plenty: 23 [23.7]	11 [16.2] 10 [10.3]	3 [4.4] 8 [8.2]	4 [5.9] 6 [6.2]

Total number of households (Lean: N=68; Plenty: N=97)

Table 27 conveys observations on food security status of study households as experienced in the past 30 days according to caregiver age during the lean season. It was observed that during the lean season, households' general concerns included insufficient food quality (≥85.3%), insufficient food intake (≥81%) and anxiety and uncertainty of food supply (76.5%). Furthermore, older caregivers struggled more with food insecurity than households of younger caregivers. Compared to younger caregiver households, most older caregiver's households worried over food supply (82.5%), were unable to eat kinds of food liked (87.5%), ate limited variety of foods than desired (80.0%), ate smaller meals than desired (82.5%), had fewer meals per day than desired (82.5%) and experienced members going to sleep hungry (60.0%). These occurrences occurred often (>10 times) between 10.0% and 52.5% in the older caregiver households compared to 0.0% and 46.4% in the younger caregiver households. On the contrary, the concerns of the younger caregiver households over those of older caregivers included eating food not wanted (78.6), having no food of any kind (57.1%) and having members go whole day and night without food (32.1%). Frequency of occurrences of the aforementioned situations occurred often in households of younger caregivers in the past month between 7.1% and 39.3%.

In summary, older caregiver households struggled more with household food insecurity than the younger caregiver ones during the lean season. Major household food insecurity concerns were different for the two groups. It was observed that the concerns of the younger caregiver households included consumption of food of compromised quality, reduced food quantity followed by anxiety over food supply in this respective order in the past month. On the contrary, it was noticed that the older caregiver households' concerns included consuming food of compromised quality, having anxiety over food supply and insufficient food quantity.

Table 27 Household food insecurity conditions and frequency of occurrence as experienced in the past month by caregiver age in the lean season

Food Insecurity Domains and Conditions experienced by Households		**Caregivers affirming condition N [%]**	**N [%] of Households**			
			Caregivers affirming condition by age	Occurred rarely 1-2 X	Occurred Sometimes 3-10 X	Occurred Often > 10 X
Anxiety and uncertainty of food supply	Worry that food is not enough	52 [76.5]	≤34 years: 19 [67.9]	11[39.3]	5 [17.9]	3 [10.7]
			≥35 years: 33 [82.5]	16 [40.0]	5 [12.5]	12 [30.0]
Insufficient Food quality	Unable to eat kinds of food liked	58 [85.3]	≤34 years: 23 [82.1]	9 [32.1]	3 [10.7]	11 [39.3]
			≥35 years: 35 [87.5]	9 [22.5]	9 [22.5]	17 [42.5]
	Ate limited variety of foods than desired	54 [79.4]	≤34 years: 22 [78.6]	3 [10.7]	4 [14.3]	13 [46.4]
			≥35 years: 32 [80.0]	7 [17.5]	3 [7.5]	21 [52.5]
	Ate food not wanted	50 [73.5]	≤34 years: 22 [78.6]	7 [25.0]	2 [7.1]	11 [39.3]
			≥35 years: 28 [70.0]	7 [17.5]	8 [20.0]	13 [32.5]
Insufficient food intake	Ever ate smaller meals than desired	55 [80.9]	≤34 years: 22 [78.6]	6 [21.4]	9 [32.1]	7 [25.0]
			≥35 years: 33 [82.5]	14[35.0]	7 [17.5]	12 [30.0]
	Fewer meals per day than desired	53 [77.9]	≤34 years: 20 [71.4]	7 [25.0]	5 [17.9]	8 [28.6]
			≥35 years: 33 [82.5]	10 [25.0]	8 [20.0]	15 [37.5]

Food Insecurity Domains and Conditions experienced by Households		**Caregivers affirming condition N [%]**	**N [%] of Households**			
			Caregivers affirming condition by age	Occurred rarely 1-2 X	Occurred Sometimes 3-10 X	Occurred Often > 10 X
	Had no food of any kind	38 [55.9]	≤34 years: 16 [57.1]	9 [32.1]	4 [14.3]	2 [7.1]
			≥35 years: 22 [55.0]	8 [20.0]	7 [17.5]	7 [17.5]
	Ever slept hungry in the past 30 days	39 [57.4]	≤34 years: 15 [53.6]	8 [28.6]	7 [25.0]	0 [0.0]
			≥35 years: 24 [60.0]	7 [17.5]	10 [25.0]	7 [17.5]
	Ever went the whole day and night without food	17 [25.0]	≤34 years: 9 [32.1]	7 [25.0]	2 [7.1]	0 [0.0]
			≥35 years: 8 (20.0]	3 [7.5]	1 [2.5]	4 [10.0]

Total number of households (Lean: N=68)

Displayed in table 28 is the food security status of the households in the past 30 days according to caregiver age during the plenty season. A recurring pattern similar to the lean season of older caregiver households being more affected by household food insecurity was observed. Thus these households experienced more anxiety and uncertainty of foods supply (72.4% vs. 56.4%), consuming food of insufficient quality (22.4% to 77.6% vs. 23.1% to 64.1%) and compromised quality (72.4% to 79.3% vs. 56.4% to 66.7%) when compared to younger caregiver households respectively. The occurrences of these severe reactions often occurred between 3.4% and 36.2% in old caregiver households compared to 7.7% and 25.9% in the younger caregiver households.

In summary, both younger and older caregiver households experienced food insecurity. However, older caregiver households generally suffered more food insecurities in both seasons although the effects were too extreme in the lean season. Both age group households experienced similar concerns of consuming food of compromised quality, having reduced food quantity and worrying about food supply in this respective order.

Table 28 Household food Insecurity conditions and frequency of occurrence as experienced in past month in the plenty season and according to caregiver age

Food Insecurity Domains and Conditions experienced by Households		**Caregivers affirming condition n [%]**	**N [%] of Households**			
			Caregivers affirming condition by age	Occurred rarely 1-2 X	Occurred Sometimes 3-10 X	Occurred Often > 10 X
Anxiety and uncertainty of food supply	Worry that food is not enough	64 [56.4]	≤34 years: 22 [56.4]	8 [20.5]	9 [23.1]	5 (12.8]
			≥35 years: 42 [72.4]	10 [17.2]	17 [29.3]	15 (25.9]
Insufficient Food quality	Unable to eat kinds of food liked	72 [74.2]	≤34 years: 26 [66.7]	9 [23.1]	10 [25.6]	7 [17.9]
			≥35 years: 46 [79.3]	10 [17.2]	16 [27.6]	20 [34.5]
	Ate limited variety of foods than desired	68 [70.1]	≤34 years: 25 [64.1]	6 [15.4]	9 [23.1]	10 [25.6]
			≥35 years: 43 [74.1]	8 [13.8]	14 [21.1]	21 [36.2]
	Ate food not wanted	64 [66.0]	≤34 years: 22 [56.4]	6 [15.4]	9 [23.1]	7 [17.9]
			≥35 years: 42 [72.4]	12 [20.7]	13 [22.4]	17 [29.3]

Food Insecurity Domains and Conditions experienced by Households		**Caregivers affirming condition n [%]**	**N [%] of Households**			
			Caregivers affirming condition by age	Occurred rarely 1-2 X	Occurred Sometimes 3-10 X	Occurred Often > 10 X
Insufficient food intake	Ever ate smaller meals than desired	70 [72.2]	≤34 years: 25 [64.1]	7 [17.9]	10 [25.6]	8 [20.5]
			≥35 years: 45 [77.6]	8 [13.8]	23 [39.7]	14 [24.1]
	Fewer meals per day than desired	65 [67.0]	≤34 years: 24 [61.5]	5 [12.8]	12 [30.8]	7 [17.9]
			≥35 years: 41 [70.7]	7 [12.1]	19 [32.8]	15 [25.9]
	Had no food of any kind	39 [40.2]	≤34 years: 14 [35.9]	4 [10.3]	7 [17.9]	3 [7.7]
			≥35 years: 25 [43.1]	8 [13.8]	12 [20.7]	5 [8.6]
	Ever slept hungry in the past 30 days	40 [41.2]	≤34 years: 13 [33.3]	6 [15.4]	2 [5.1]	5 [12.8]
			≥35 years: 27 [46.6]	10 [17.2]	9 [15.5]	8 [13.8]
	Ever went the whole day and night without food	22 [22.7]	≤34 years: 9 [23.1]	5 [12.8]	2 [5.1]	3 [7.7]
			≥35 years: 13 [22.4]	5 [8.6]	6 [10.3]	2 [3.4]

Total number of households (Plenty: N=97)

Table 29 reports observations on the food security status of the households in the past 30 days according to farming type during the lean season. Farming households' general concerns included insufficient food quality (73.5% to 85.3%), insufficient food intake (25.0% to 80.9%) and anxiety and uncertainty of food supply (76.5%) in this respective order. Furthermore, a general observation was that *non-molapo* households struggled more with food insecurity than did *molapo* farming households. Surprisingly, although *molapo* households were less likely to experience food insecurity conditions compared to non-molapo ones, they however often (>10 times) had more occurrences. *Non-molapo* farming households were generally concerned with consumption of food of poor quality (73.7% to 86.8%), decreased food quantity (26.3% to 81.6%) and household food supply (71.7%) in this respective order. In comparison, *molapo* households' concerns included household food supply (83.3%), consumption of food of poor quality (73.3% to 83.3%) and decreased food quantity (23.3% to 80.0%).

Table 29 Household food insecurity conditions experienced in past month and frequency of occurrence by farming type in lean season

Food Insecurity Domains and Conditions experienced by Households		**Caregivers affirming condition n [%]**	**N [%] of Households**			
			Caregivers affirming condition by farming	Occurred rarely 1-2 X	Occurred Sometimes 3-10 X	Occurred Often > 10 X
Anxiety and uncertainty of food supply	Worry that food is not enough	52 [76.5]	*Molapo*: 25 [83.3]	15 [50.0]	2 [6.7]	8 [26.7]
			N. Molapo: 27 [71.1]	12 [31.6]	8 [21.1]	7 [18.4]
Insufficient Food quality	Unable to eat kinds of food liked	58 [85.3]	*Molapo*: 25 [83.3]	6 [20.0]	4 [13.3]	15 [50.0]
			N. Molapo: 33 [86.8]	12 [31.6]	8 [21.1]	13 [34.2]

Food Insecurity Domains and Conditions experienced by Households		**Caregivers affirming condition n [%]**	**N [%] of Households**			
			Caregivers affirming condition by farming	Occurred rarely 1-2 X	Occurred Sometimes 3-10 X	Occurred Often > 10 X
	Ate limited variety of foods than desired	54 [79.4]	*Molapo*: 26 [86.7]	3 [10.0]	3 [10.0]	18 [60.0]
			N. Molapo: 28 [73.7]	7 [18.4]	4 [10.5]	16 [42.1]
	Ate food not wanted	50 [73.5]	*Molapo*: 22 [73.3]	4 [13.3]	3 [10.0]	13 [43.3]
			N. Molapo: 28 [73.7]	10 [26.3]	7 [18.4]	11 [28.9]
Insufficient food intake	Ever ate smaller meals than desired	55 [80.9]	*Molapo*: 24 [80.0]	7 [23.3]	8 [26.7]	9 [30.0]
			N. Molapo: 31 [81.6]	13 [34.2]	8 [21.1]	10 [26.3]
	Fewer meals per day than desired	53 [77.9]	*Molapo*: 23 [76.7]	9 [30.0]	1 [3.3]	13 [43.3]
			N. Molapo: 30 [78.9]	8 [21.1]	12 [31.6]	10 [26.3]
	Had no food of any kind	38 [55.9]	*Molapo*: 16 [53.3]	7 [23.3]	5 [16.7]	4 [13.3]
			N. Molapo: 22 [57.9]	10 [26.3]	6 [15.8]	5 [13.2]
	Ever slept hungry in the past 30 days	39 [57.4]	*Molapo*: 17 [56.7]	7 [23.3]	7 [23.3]	3 [10.0]
			N. Molapo: 22 [57.9]	8 [21.1]	10 [26.3]	4 [10.5]

Food Insecurity Domains and Conditions experienced by Households		**Caregivers affirming condition n [%]**	**N [%] of Households**			
			Caregivers affirming condition by farming	Occurred rarely 1-2 X	Occurred Sometimes 3-10 X	Occurred Often > 10 X
	Ever went the whole day and night without food	17 [25.0]	*Molapo*: 7 [23.3]	2 [6.7]	3 [10.0]	2 [6.7]
			N. Molapo: 10 [26.3]	8 [21.1]	0 [0.0]	2 [5.3]

Total number of households (Lean: N=68)

Table 30 displays the food security status of the households in the past 30 days according to farming type but in the plenty season. A different pattern was observed. Instead of *non-molapo* farming households being more affected by food insecurity, *molapo* farming households were the ones struggling more. Major *molapo* farming households concerns included insufficient food quantity (20.0% to 82.0%), consuming food of compromised quality (70.0% to 76.0%) and anxiety and uncertainty of foods supply (68.0%). In comparison, non-*molapo* farming households concerns included consuming food of compromised quality (61.7% to 72.3%), anxiety and uncertainty of foods supply (63.8%) and insufficient food quantity (25.5% to 61.7%). Similarly, *molapo* (between 6.0% and 44.0%) households often experienced these occurrences than *non-molapo* ones (4.3% and 19.1%).

Overall, all households experienced food insecurity irrespective of season, caregiver age and/or farming systems. Compelling observations were made (Figure 15). For instance, generally the lean season had major concerns in all 3 areas being anxiety over food supply, consumption of food of compromised quality and reduced food quantity. It was also noticed that older caregiver households persistently experienced all 3 major concerns compared to the younger caregiver households. Furthermore, these older caregiver households tended to have such concerns more often.

Overall, *molapo* farming households seemed to be equally concerned in all the 3 areas except for a slight ease up on reduced food quantity during the lean season when compared to the counterpart. Reports of having these occurrences often reached the highs of 60% on the concern of food quality during the lean season.

Major Household Food Concerns	By Season		By Caregiver Age				By Farming Type			
			≤34 Years		≥35 Years		Molapo		Non-Molapo	
	Lean	Plenty	Lean	Plenty	Lean	Plenty	Lean	Plenty	Lean	Plenty
Food Supply Anxiety	↑	↓	↓	↓	* ↑	* ↑	* ↑	* ↑	↓	↓
Poor Food Quality	↑	↓	↓	↓	* ↑	* ↑	** ↑	* ↑	↑	↓
Insufficient Food Quantity	↑	↓	↓	↓	* ↑	* ↑	↓	* ↑	↑	↓

Bolded arrows show major food insecurity concerns between counterparts. * means “often” occurrences; ** often occurrences reaching 60%

Figure 15 Summary of major household food insecurity concerns according to season, caregiver and farming type

Table 30 Household food insecurity conditions experienced in past month and frequency of occurrence by farming type in plenty season

Food Insecurity Domains and Conditions experienced by Households		**Caregivers affirming condition n [%]**	**N [%)] of Households**			
			Caregivers affirming condition by farming	Occurred rarely 1-2 X	Occurred Sometimes 3-10 X	Occurred Often > 10 X
Anxiety and uncertainty of food supply	Worry that food is not enough	64 [66.0]	*Molapo*: 34 [68.0]	10 [20.0]	11 [22.0]	13 [26.0]
			N. Molapo: 30 [63.8]	8 [17.0]	15 [31.9]	7 [14.9]
Insufficient Food quality	Unable to eat kinds of food liked	72 [74.2]	*Molapo*: 38 [76.0]	9 [18.0]	10 [20.0]	19 [38.0]
			N. Molapo: 34 [72.3]	10 [21.3]	16 [34.0]	8 [17.0]
	Ate limited variety of foods than desired	68 [70.1]	*Molapo*: 36 [72.0]	7 [14.0]	7 [14.0]	22 [44.0]
			N. Molapo: 32 [68.1]	7 [14.9]	16 [34.0]	9 [19.1]
	Ate food not wanted	64 [66.0]	*Molapo*: 35 [70.0]	9 [18.0]	10 [20.0]	16 [32.0]
			N. Molapo: 29 [61.7]	9 [19.1]	12 [25.5]	8 [17.0]
Insufficient food intake	Ever ate smaller meals than desired	70 [72.2]	*Molapo*: 41 [82.0]	10 [20.0]	19 [38.0]	12 [24.5]
			N. Molapo: 29 [61.7]	5 [10.6]	14 [29.8]	11 [22.9]
	Fewer meals per day than desired	65 [67.0]	*Molapo*: 37 [74.0]	6 [12.0]	17 [34.0]	14 [28.0]
			N. Molapo: 28 [59.6]	6 [12.8]	14 [29.8]	8 [17.0]

Food Insecurity Domains and Conditions experienced by Households		**Caregivers affirming condition n [%]**	**N [%)] of Households**			
			Caregivers affirming condition by farming	Occurred rarely 1-2 X	Occurred Sometimes 3-10 X	Occurred Often > 10 X
	Had no food of any kind	39 [40.2]	*Molapo*: 19 [38.0]	7 [14.0]	8 [16.0]	4 [8.0]
			N. Molapo: 20 [42.6]	5 [10.6]	11 [23.4]	4 [8.5]
	Ever slept hungry in the past 30 days	40 [41.2]	*Molapo*: 22 [44.0]	10 [20.0]	5 [10.0]	7 [14.0]
			N. Molapo: 18 [38.3]	6 [12.8]	6 [12.8]	6 [12.8]
	Ever went the whole day and night without food	22 [22.7]	*Molapo*: 10 [20.0]	4 [8.0]	4 [8.0]	3 [6.0]
			N. Molapo: 12 [25.5]	6 [12.8]	4 [8.5]	2 [4.3]

Total number of households (Plenty: N=97)

Hypothesis: There is no significant difference in the mean HFIAS scores when compared by seasons, age and farming types.

Table 31 presents the mean HFIAS scores and corresponding significance according to season. There was no statistical significant difference observed in the seasonal mean HFIAS scores (lean: 12.2 ± 0.9 and plenty: 11.0 ± 0.8, t (163) = 1.089, p>0.05). The null hypothesis was not rejected thus confirming a lack of statistical significant difference between the mean HFIAS scores and consequently household food security status across seasons.

Table 31 Mean HFIAS scores and significance according to season

Food Security Parameter	Season	N	Mean	SE	Mean Difference	T	DF	Sig (2) tailed
HFIAS Scores	Lean	68	12.235	0.9	1.287	1.089	163	0.278
	Plenty	97	10.949	0.8				

*Significance at *p*-value <0.05

Table 32 displays the mean HFIAS scores and corresponding significance according to caregiver age in the respective seasons. There was no statistical significant difference in the mean HFIAS scores observed when comparing by caregiver age in the different seasons (*lean*: ≤34 years: 11.5 ± 1.4 and ≥35 years: 12.8 ± 1.2, t (66) = -0.687, p>0.05) as compared to the plenty season (*plenty*: ≤34 years: 9.6 ± 1.3 and ≥35 years: 11.8 ± 1.0, t (95) = -1.433, p>0.05). The null hypothesis is therefore not rejected thus confirming lack of statistical significance in the mean HFIAS scores and consequently household food security status when compared by age in the different seasons.

Table 32 Mean HFIAS scores and significance according to age

Food Security Parameter	**Season**	**Age group**	**N**	**Mean**	**SE**	**Mean Difference**	**T**	**DF**	**Sig (2) tailed**
HFIAS Scores	Lean	≤34 yrs	28	11.500	1.4	-1.250	-0.687	66	0.495
		≥35 yrs	40	12.750	1.2				
	Plenty	≤34 yrs	39	9.615	1.3	-2.229	-1.433	95	0.155
		≥35 yrs	58	11.845	1.0				

*Significance at *p*-value <0.05

Table 33 presents the mean HFIAS scores and corresponding significance according to farming type in the respective seasons. There was no statistical significant difference in the mean HFIAS scores of the children in the different farming types in all the seasons (*lean*: *molapo*: 7.7 ± 1.4 and *non-molapo*: 7.1 ± 1.1, t (66) = 0.560, p>0.05) and (*plenty*: *molapo*: 12.0 ±1.1 and *non-molapo*: 9.9 ± 1.1, t (95) = 1.366, p>0.05). The null hypothesis was not rejected for either season confirming the lack of statistical significant difference in the mean HFIAS scores and/or consequently household food security status when compared by farming types.

Table 33 Mean HFIAS scores and significance according to farming type

Food Security Parameter	**Season**	**Age group**	**N**	**Mean**	**SE**	**Mean Difference**	**T**	**DF**	**Sig (2) tailed**
HFIAS Scores	Lean	*Molapo*	30	7.797	1.4	1.011	0.560	66	0.578
		N. Molapo	38	7.064	1.1				
	Plenty	*Molapo*	50	11.960	1.1	2.088	1.366	95	0.175
		N. Molapo	47	9.872	1.1				

* Significant at *p*-value< 0.05

Factors influencing food insecurity

Table 34 displays factors that may influence food insecurity in households where study children resided during the study period. Only one factor, household income, was statistically significant in the influence of household food insecurity. This factor was negatively associated with household food security. This implied that with every unit increase in household income, households were 0.242 times less likely to be food secure thus reducing food security by about 24%. Other factors were not statistically significant.

Table 34 Factors influencing household food security

Variable contribution to household food insecurity	Reference:	ß	Sig.	Exp (ß)	95% C.I for Exp (ß)	
					Lower	Upper
Seasonality	Plenty vs. **Lean season**	0.504	0.299	1.655	0.640	4.282
Farming type	*Non-Molapo* vs. ***Molapo***	0.732	0.388	2.078	0.394	10.957
Study village	Shorobe vs. **Tubu**	0.204	0.821	1.227	0.208	7.223
Caregiver age	≤34 vs. **≥35 years**	0.516	0.269	1.675	0.672	4.176
Caregiver marital status	Living without vs. **Living with partner**	0.147	0.757	1.158	0.458	2.929
Household income	No vs. **Yes**	-1.420	0.005*	0.242	0.090	0.652
Harvest lasting till next seasons	Harvest not vs. **Harvest lasted**	-0.618	0.238	0.539	0.193	1.505
Food aid in the past 3 months	No vs. **Yes**	0.110	0.841	1.116	0.379	3.286
Household size	≥ **5** vs. ≤4 members	-1.002	0.102	0.367	0.111	1.219

*significance at p<0.05; Dependent variable: household food security; bolded means reference used to interpret likelihood of event happening

Caregiver characteristics influencing child nutritional status

Table 35 displays factors, specifically caregiver characteristics that could potentially influence child nutritional status. According to the results, none of the factors were statistically significant at influencing child nutritional status implying a possible influence of external factors not studied.

Table 35 Caregiver characteristics influencing child nutritional status

Variable contribution to child nutritional status	Reference	**ß**	**Sig.**	**Exp (ß)**	**95% C.I for Exp (ß)**	
					Lower	**Upper**
Caregiver marital status	Living without vs. **Living with partner**	-0.458	0.532	0.633	0.151	2.659
Caregiver education	No education vs. **Some education**	-0.925	0.449	0.397	0.036	4.357
Caregiver age	≤34 vs. **≥ 35 years**	-0.038	0.960	0.963	0.218	4.252
Presence of guardian during meal time	No vs. **Yes**	0.525	0.469	1.690	0.409	6.995
Caregiver receiving food aid	No vs. **Yes**	-0.266	0.762	0.766	0.137	4.277
Household size	≥ 5 vs **≤4 members**	-1.083	0.220	0.339	0.060	1.911
Toilet availability	No toilet and use bush vs. **use some form of toilet**	-0.791	0.295	0.453	0.103	1.991

*significance at p<0.05; Dependent variables: child being stunted; bolded means reference used to interpret likelihood of event happening

Factors influencing child health environment and services access

Table 36 presents factors that may influence the health environment and services around the child. None of the factors were statistically significant in influencing the health environment and services around the child.

Table 36 Factors influencing health environment and services around the child

Variable contribution to health environment and services	Reference	ß	Sig.	Exp (ß)	95% C.I for Exp (ß)	
					Lower	Upper
Caregiver Marital Status	Living without vs. **Living with partner**	-0.410	0.567	0.664	0.163	2.700
Caregiver Education	No Education vs. **Some Education**	-0.862	0.443	0.422	0.047	3.823
Household Size	≥5 vs **≤4 members**	-1.173	0.190	0.309	0.054	1.787
Toilet availability	No toilet use bush vs. **Use some form of toilet**	-0.912	0.224	0.402	0.093	1.745
Action taken when child ill	No action vs. **Taken to health facility**	-0.577	0.453	0.562	0.125	2.531

*significance at p<0.05; Dependent variable: Child being stunted; bolded means reference used to interpret likelihood of event happening

Summary of null hypothesis tested

Table 37 summarizes all the null hypotheses tested, statistical tests used and decision reached. The information is as follows:

Table 37 Summary of null hypothesis tested

Null Hypothesis	Statistical Test	Decision	Findings
There are no significant differences in the WAZ, HAZ and BAZ means according to seasons, farming types and age	Independent Samples T-Test	a. HAZ (Do not reject by season, child age and/or by farming type) b. WAZ (Reject by season, cannot be established by child age and do not reject by farming type) c. BAZ [<-2SD] (Do not reject by season, do not reject by child age in the lean season, reject by child age in the plenty season, do not reject by farming type)	a. HAZ not influenced by season, child age and/or farming type b. WAZ influenced by season c. BAZ influenced by child age in the plenty season

Null Hypothesis	Statistical Test	Decision	Findings
There is no significant difference in the mean HDDS when compared by seasons, age and farming types	Independent Samples T-Test	a. Reject by seasons, reject by child age and do not reject by farming type in the lean season but reject in the plenty season.	a. HDDS influenced by season and farming type in the plenty season
There are no significant differences in the mean serum Hb, ferritin and zinc levels when compared by seasons, age and farming types	Independent Samples T-Test	a. Statistical significance could not be established for both iron and zinc due to insufficient data for comparison	Not applicable
There are no significant differences in the mean intensity of infection (epg) of detected STH according to seasons, age and farming types	Independent Samples T-Test	a. Statistical significance could not be established as only one child presented with STH	Not Applicable

Null Hypothesis	Statistical Test	Decision	Findings
There is no relationship between the mean intensity of infection (epg) of detected STH and Hb and ferritin levels when compared by seasons, age and farming types	Independent Samples T-Test	a. Relationship could not be established due to insufficient data	Not applicable
There is no significant difference in the mean HFIAS scores when compared by seasons, age and farming types	Independent Samples T-Test	a. Do not reject by season, caregiver age and/or farming type.	HFIAS not influenced by season, caregiver age and/or farming type
There is no difference in the factors influencing dietary patterns, health status, household food insecurity, caregiver child care, health environment and services	Binary logistic regression	a. Not applicable	Not applicable

Summary of factors influencing nutritional status

Table 38 displays the summary of all the factors found to influence child nutritional status.

Table 38 Summary of Factors influencing different components of nutritional status

Components Factors Tested On	Test Used	Findings On Potential Influencing Factors
Stunting	Binary logistic regression	None
Underweight	Binary logistic regression	None
Thinness	Binary logistic regression	Child age (6 to 9 year olds)
Dietary diversity	Binary logistic regression	Household income [-], seasonality (plenty) [-], farming type (Molapo farming) [+], village (Tubu) [-]
Household food security	Binary logistic regression	Household income [-]
Caregiver characteristics influencing child nutritional status	Binary logistic regression	None
Health environment and service	Binary logistic regression	None

CHAPTER 5 DISCUSSION

Manifestation of nutritional status

Poor nutritional status was observed in study children with manifestation of stunting, underweight, thinness and OW/OB irrespective of season, age and/or farming system. The coexistence of both undernutrition and overnutrition in the same study population are suggestive of a common worldwide problem of double burden of malnutrition. So far no nation seems to be exempted (Demaio, 2018). The double burden of malnutrition problem has not exempted the SAC around the world also. For example, SAC in Iran presented with underweight, stunting, overweight and obesity prevalence of 13.9%, 30.0%, 10.4% and 5.7% respectively (Jafari et al, 2014). In Sudan SAC also had undernutrition and overnutrition estimated at 7.1%, 23.1% and 7.1% prevalence of stunting, thinness and OW/OB respectively (Mohammed and Hussein, 2015). For SAC in the neighbor country South Africa, stunting, underweight, thinness and OW/OB prevalence of 5%, 6%, 6% and between 10% and 12% respectively were observed (Kimani-Murange, 2012). The double burden of malnutrition may generally be due to rapid nutrition transition affecting diets and behavioural changes inclusive of sedentary lifestyles (Demaio, 2018). However, the double burden of malnutrition in the current study as characterized by underweight [12.3%], stunting [6%], thinness [11.9%] and OW/OB [4.8] during the lean season versus 6.3%, 5.2%, 7.4% and 4.4% respectively in the plenty season could be explained by the community's preference for refined foods from shops over usual farm produce. Both adults and children would identify store bought foods such as rice, mayonnaise, polony etc as "nice foods" during interviews.

Due to lack of comparison data in the nation and Ngamiland District on SAC, these results were compared to national under-fives malnutrition prevalence. Fluctuations were observed in the comparison between SAC and under-fives (CSO/UNICEF, 2009; World Bank, 2011; Stevens et al, 2013; Scaling up Nutrition, 2018). During the lean season, only the underweight prevalence seemed comparable [study: 12.3% vs. national: 11.9%] whereas stunting was very low [study: 6.0% vs national: 31.4%], wasting was high [study: 11.9% vs national: 7.2%] and OW was low [study: 4.8% vs. national: 11.2%]. Nationally, older children aged above 15 years were estimated to have an OW/OB prevalence of 48% (Central Statistics Office, 2009). Comparing this prevalence to that of the current study, it was evident that OW/OB in the study children was not much of a health concern. In the plenty season, only the wasting prevalence was comparable [study: 7.4% vs. national: 7.2%] whereas underweight, stunting and OW/OB were low (study: 6.3% vs. national: 11.9%), (study: 5.2% vs. national: 31.4%) and (study: 4.4% vs. national: 11.2%) respectively.

Two observations can be made from these results. Firstly, it seems acute malnutrition as indicated by underweight and wasting in under-fives and/ or thinness in SAC may show variations dependent on seasonality. This observation was indicated by increased and decreased prevalence in the lean and plenty seasons respectively when compared to national prevalence. Secondly, SAC generally seemed to have an improved nutritional status compared to the under-five population.

Although no evidence currently exists to support this notion, the researcher has reason to believe that the under-fives malnutrition rates may be overestimated for long. Two reasons are given to support this statement.

Firstly, current malnutrition rates are reported from old survey datasets, one main one being the Botswana and Family Health Survey of 2009 (CSO/UNICEF, 2009). Thereafter, what would seem like recent work would actually be recent citations from this same data (World Bank, 2011; Food and Nutrition Technical Assistance III (FANTA III), 2013; Stevens et al, 2013; Scaling up Nutrition, 2018). Other work in the country also give lower prevalence indicating that there is a probable chance of overestimation if we continue to use such old datasets. The aforementioned work had no prevalence of over 12.0% in stunting, underweight, thinness and/or overweight (National Food Technology Research Centre, unpublished). Another study that used anthropometrics in children aged 3 to 5 years showed that undernutrition (represented by wasting) and overnutrition (represented by OW) were 5.6% and 2.5% respectively in the Southern and Northern regions of Botswana (Ramolefhe-Mutumwa et al, 2020). Even the study by Abrams et al, (2003) on SAC showed stunting and thinness prevalence levels of 8.4% and 6.7% respectively.

Secondly, the fourth national demographic survey has been conducted in 2017 and the report produced therefrom provided child nutritional status estimates of breastfeeding and complementary feeding only. Thus there are no current estimates of the country’s child malnutrition status. It is the researcher’s belief that with the analysis of the remaining data coupled with the effect from Botswana government interventions and safety nets for her children and people, then a different picture from what is the norm may be seen.

When malnutrition in this study was compared to that of the neighboring country, South Africa, it seemed that undernutrition and not overnutrition was more prevalent. The differences which are observed in the OW/OB prevalence could be due to the higher standards of living and probably more availability and accessibility of foods especially convenience foods in South Africa.

On the global scale, the study children fared better to other regions. Stunting levels in all regions of the world are estimated at almost 30% whereas OW/OB is at 16% (Best et al, 2010; Fiorentino, 2015).

The low prevalence of OW/OB in this study could point to the slow permeation of nutrition transition in to the rural areas and or the compacted problem of food insecurity and poor meal patterns. Moreover, since most households are dependent on subsistence farming, they may not have the luxury of excess food and/or of high purchasing power to procure more food.

Differences of anthropometric measures by season, age and farming system

When assessing mean growth parameters by season, age and farming system, it was noticed that no statistical significant difference existed with most parameters except WAZ by season and BAZ by age. These results are discussed as follows:

WAZ by season

A significant difference was observed in underweight prevalence when compared by season with a lesser mean in the plenty season. This implied deterioration of nutritional status during the plenty season. A closer look at the WAZ means in the different seasons indicated that SAC were likely to be underweight during the plenty season. This was unexpected as usually the plenty season is associated with abundance of food (Oduor et al, 2019). However, similar results were obtained in a Malawian study where children were significantly underweight in the plenty season than the lean season (Chikhungu and Madise, 2014). Although the explanation for the observation was child morbidity than food availability, the latter could hold true for this study coupled with poor feeding practices. When interviewed, the majority (>83.0%) of caregivers in the study indicated having inadequate harvests that could sustain them to the next harvesting season implying a level of food shortage in the households. Previous work in the study areas also showed poor feeding practices amongst under-fives (Ramolefhe et al, 2011). It is likely that SAC may be facing the same challenge. An underweight child is at risk of compromised immune system and can easily acquire infections which increase chances of morbidity and mortality (Uzogara, 2016). It has also been shown that underweight children may also experience low energy which may result in fatigue, reduced reaction times, and difficulty in learning and / or being attentive thus leading to poor academic performance for school children, having an indirect negative bearing on the future. It has been shown that an adult who was malnourished as a child would likely earn at least 20% less on average than those who did not suffer from malnutrition (Grantham-McGregor et al, 2007; Save the Children, 2012).

BAZ by age

Further assessment of thinness was conducted by age. It was demonstrated that thinness was higher in the younger age group of 6 to 9 years especially in the plenty season. The results were also affirmed by the binary modelling which indicated that with each one year increase in age, children 6 to 9 years were 3.079 times more likely to become thin by 8%. Thinness is an indication of either acute malnutrition and/or current illness effects (WHO, 2009). Although contrary to expectation, these results are in agreement with other work elsewhere (Chikhungu and Madisa, 2014). Two reasons can be used to explain the results. Firstly, SAC who are undergoing an active growing period from preadolescence to adolescence incur physical changes that if not properly nourished may suffer from being thin (Esaulenko et al, 2017). Also, younger children would likely respond more quickly to changes in both dietary intake and/or health status. Secondly, although thinness indicates short-term sensitivity to diseases and/or effects of diseases, it is also sensitive to food shortages and/or caloric intake. Study households experienced food insecurities and shortages due to loss of crops to floods which is an indicator of climate change and which occurred in the high flood season of 2010 to 2011 (National Hydrological Services Botswana, 2013). The high flood season coupled with high water table in one of the study sites, resulted in delayed crop cultivation and planting as water did not recede on time. For those fields which were planted, water logging resulted in crop damage, limiting food availability in the farming households and resulting in poor nutritional status of the SAC and respective communities (Esaulenko et al, 2017).

Thinness is harmful to the child's wellbeing as it exacerbates the risk of infection in children which can lead to an array of malfunctions such as loss of appetite, inability to absorb nutrients well, inability to pay attention and/ or perform well at school and to have a compromised immune system. It may also lead to a cascade of other events which may not only lead to loss of manpower which translates to low productivity as an adult and compromised economy of the nation but could also result in the death of the child. (Smith and Haddad, 2015). This results are in agreement with Herrador et al, (2014) and Erismann et al, (2017) studies which registered close to 20% prevalence of thinness in children over 10 years.

Immediate Determinants

This level of determinants of child nutritional status in the framework focuses on dietary intake and child health status and factors that influence them.

Meal patterns

In assessing the meal patterns of the study children it was observed that regardless of season, age, and/or farming system, the bulk of the children's diets were predominantly made of energy dense foods such as cereals, miscellaneous food staffs (condiments, beverages such as tea and coffee), sugar/honey, meat/poultry/offal, oils/fats and milk and milk products. Overall, no more than 27% of all children irrespective of season, age and/or farming system had representation of roots and tubers, vegetables, fruits, eggs, fish and seafood and pulses/legumes/nuts in the diets. As much as dietary diversity in the study is measured by representation of food groups in the children's diets, it is noteworthy that the bulk of food groups represented was more energy dense and less nutrient-dense.

These meal patterns seemed to mirror that of other studies in the nation showing increased consumption of cereals and miscellaneous foods and less of nutrient dense foods such as fruits and vegetables (MoH, 1996; Maruapula and Chapman-Novakofski, 2007, Ramolefhe et al, 2015).

Another critical point that ought to be considered yet it wasn't measured in this study was the quantity consumed of these groups. With the observed high prevalence of malnutrition in the study children, quantity and quality of food consumed might have been compromised. Quality and quantity of these food groups is important to maintain healthy growth. For instance, if carbohydrates mostly ingested are refined, there could be too much energy deposited in the body leading to weight gain. Furthermore, anti-nutrients such as phytates may inhibit and/or reduce absorption of other nutrients such as iron and zinc (Popova and Mihaylova, 2019).

Also, if protein foods are from milk as it was in this study, there could have been an interruption with absorption of certain nutrients. Casein, a protein in milk may have a modest inhibitory effect on zinc absorption when compared with other protein sources (Saunders et al, 2013). This implied that although children may have had high representation of cereal from carbohydrates and proteins from milk, it may be questionable as to whether they absorbed enough nutrients as required.

Another aspect observed among the meal patterns of the children was the monotonousness of diets for all children irrespective of season, age and/ or farming system. This observation seemed common amongst SAC as shown in other studies (Gewa et al, 2014; Katungwe et al, 2015). Intake of animal food sources was generally low which is similar to MoH (1996) study. Low consumption of meat in the study children is not a surprise as livestock killing for consumption in the home is rare except on special occasions.

Livestock especially cattle are the pride and livelihood pillars of Batswana (Arntzen, 2005); hence it is not easy to butcher for relish. The study areas also are prone to cattle lung disease, which periodically limits meat intake (Arntzen, 2005).

Of concern was the lack of consumption of nutrient dense foods such as roots and tubers, vegetables, fruits, eggs, fish and seafood and pulses/legumes/nuts. This was in agreement with work previously done in the country ((MoH, 1996; Maruapula and Chapman-Novakofski, 2007, Ramolefhe et al, 2015). Eating these nutrient dense foods in childhood provides a platform for children to develop healthy eating behaviors that run into adulthood (Steyn, 2010).

Furthermore, food from these groups provide micronutrients that assists the body in functioning optimally. The problem of inadequate fruits and vegetables seems to be a global problem. It has been shown that even young people in the United States also fail to meet the recommendations of eating 2.5 to 6.5 cups of fruits and vegetables respectively each day (CDC, 2017).

Differences of meal patterns according to season, age and/or farming system

There was a significant difference in meal patterns (dietary diversity) when compared according to season and farming system in the plenty season. It was shown that food group intake was better in the lean (5.5) than in the plenty season (4.4). These results were in agreement with previous work by the Ministry of Health (1996) which showed that dietary intake was influenced by seasonality except on cereal consumption which remained the same. The findings of the current study were contrary to expectation. It is expected that the plenty season would have more food variety than in the lean. However, this may indicate the impact of challenges incurred by the community during the study period. From 2010 up till 2012, there were massive floods although they reached study sites at different times (Expert Africa, 2017).

In 2010, the floods were described as "strong" and they resulted from early local rains and then worsened by late Angolan floodwaters. The following year of 2011, floods were described as "very strong" and were worsened by finding the Delta already saturated from the previous two high flood years.

In 2012, although flood levels seemed to return to normal, they could not escape the three strong flood years which had occurred prior to it. These floods affected many fields resulting in crop damages at the earliest stages of the flood. This explained why the lean season fared better off than the plenty season.

The same challenge could also explain why there was a statistically significant difference observed in the plenty season when comparison was done by farming system. Results showed that *molapo* farming had lower dietary diversity (4.2 food groups) than *non-molapo* farming households (4.8 food groups). Clearly, the often known to be productive farming system had suffered due to unreliability of the ecosystem which is an indicator of climate change in the study areas.

The binary modelling showed that four factors influenced dietary diversity and or meal patterns. These included household income, seasonality (plenty), association with Tubu and molapo farming. The likelihood of the child consuming 6 or more food groups when a household has adequate income was rather reduced by 11%. This came not as a surprise. Literature has showed that having income does not always guarantee adequate food and that income may be directed to other means not necessarily benefiting the child's nutrition (Kirk et al., 2018). Also, the money may be used to buy less nutrient dense foods which contribute minimally to the optimal nutritional status of the child. This result is suggestive that these rural communities are not dependent on the usual necessities of today's lifestyles such as having purchasing power.

It may also show an inseparable lifestyle irrespective of farming types. For instance, reported intake was same for all children from the different farming system households. Farmers from all systems may be producing and living off same crops (Bendsen, 2002; Vanderpost, 2009). Furthermore, both types of farming system communities may be helping each other to recuperate from shocks caused by climatic challenges. Study households were shown to be larger and therefore it may mean that the size is not compatible to the money being received. This is even influenced by the fact that most caregivers held informal jobs which pay meagrely and cannot help to improve the dietary diversity of the households.

Seasonality also influenced child dietary diversity. It was found that with every plenty season, a child's chances of eating 6 or more food groups reduced by 9%. This finding that seasonality influences child dietary diversity was also found elsewhere (Hirvonen et al, 2015; Herrador et al, 2015). The loss of crops to floods, an indicator of climate change could explain the anomaly. The high flood season coupled with high water table in one of the study sites, resulted in delayed crop cultivation and planting as water did not recede on time. For those fields which were planted, water logging resulted in crop damage, limiting food availability in the farming households and resulting in poor nutritional status of the SAC and respective communities (Bosekeng et al, 2017).

It was also observed from the results that a child associated with Tubu was less likely to consume 6 and/or more food groups implying compromised dietary diversity by 10%. Tubu is largely a *molapo* farming village that is amongst the first places to get inundation. Depending on Angolan highlands rainfall, the timing and level of the flood may be too much in Tubu making it more prone to flooding (Vanderpost, 2009).

This means that if the floods were to find half ripe crops, they may get damaged compromising food availability compromising dietary diversity of the households.

On the contrary, a child related to *molapo* farming, was likely to consume 6 and/ or more food groups by 44% compared to counterparts. It may appear contradictory that *molapo* farming positively influences dietary diversity by 44% yet Tubu village, a predominantly *molapo* farming village was previously cited to negatively influence dietary diversity. However, evidence shows that *molapo* farming is a productive system in the absence of shocks that compromise the system's productivity (Kashe et al., 2015).

When conditions are conducive, crop yield may be adequate to feed households as well as make profit that can be used to increase the dietary diversity of households.Another reason that *molapo* could be positively associated with dietary diversity may be due to the extra natural resources that come along with increased inundation. For instance as much as the flooding may be detrimental to crop health, there are still other benefits that come along with increased water flow. This include more fish and other edible natural resources such as tswii, which the households can augment their diets with (Magole and Thapelo, 2005; Soffar, 2016).

Serum iron status

Anemia

The assessment of iron status indicated that anemia as defined by hemoglobin levels below 115g/L was becoming a problem of health significance amongst study children as evidenced by a doubling prevalence of 17.4% in the lean to 34% in the lean season. In terms of age, 2 children per age group (11.8% <11 years and 33.3% ≥11 years) were found to be anemic.

Also more *molapo* farming children (n=3, 37.5%) had anemia compared to *non-molapo* farming children (n=1, 17.4%) during the lean season. In the plenty season, still more *molapo* farming (n=10, 34.5%) children had anemia compared to *non-molapo* farming children (n=8, 33.3%). This prevalence was classified as medium to very high public health significance (WHO, 2010).

Study results are higher than Abrams (2003) study and van Stuijvenberg (1999) in which SAC in Botswana (< 11%) and Namibia (< 30%) were shown to have lower prevalence of anemia even with intervention studies where children were fed fortified drinks and biscuits respectively.

The current study results agreed with a similar study in northern Benin where anemia in SAC doubled between seasons (Mitchkpe et al, 2010). Dietary iron intake and to some extent infections were suggested as causes of anemia in Beninese SAC. However, such conclusions could not be reached in this study because STH was not a problem. Furthermore, the problem was compounded by lack of ferritin values in the plenty season to identify if iron deficiency was the cause. Even with ferritin values in the lean season, it still could not be identified if iron deficiency was caused by dietary hence speculations that other causes could be responsible causes for anemia in children.

STH cannot be factored as a possible cause as only one child presented with hookworm with light intensity infestation. Study results on anemia are close to Porniammongkol et al, (2011) who identified anemia prevalence of 31% amongst adolescent boys aged between 7 and 15 years but lower than children aged 5-18 years in Cote d'Ivoire at 47% (Bleyere et al, 2013). In both seasons both age groups experienced a doubling effect of anemia. It could be that the consumption of bioavailable heme iron from meat/poultry/offal was of inadequate quantity despite a high number of the children reporting consumption of this food group in the previous 24 hours to the interview day.

For example, it seemed 70.3% and 64.6% of the younger age group and 81.5% and 56.4% of the older age group reported eating meat/poultry/offal in the past 24 hours to the interview day. If this was a true trend of how the children ate and if indeed consumption was adequate, anemia should not have been a problem. However, even with increased representation of children reporting consumption of foods from this food group, anemia levels were still high. It could be assumed that probably the intake was not adequate.

Another reason could be misreporting due to fear of being looked down upon as poor and unable to afford meat. For instance, older children (81.5%) in lean season reported consuming food from this food group but they were the ones with a higher prevalence. Differences by season, age and farming system could not be established due to insufficient information.

Serum zinc status

In assessing zinc status amongst study children, it appeared that zinc deficiency was not a health concern amongst study children, with only one child (5.0%) less than 10 years in the lean season presenting with levels below 9.9umol/L. These results in comparison to Abrams et al, (2003) study showed agreement with the prevalence observed in the experimental group (4.6%) which was fed a fortified drink than in the control cohort (14.5%). For the current study to mirror that of children given fortified drink, it was proof enough that zinc deficiency was not a problem. The low stunting rates of < 6% in both seasons also support the prediction that zinc deficiency was not a health concern (Liu et al, 2017).

These results are also similar to Australian children but different from those in Ethiopia (Amare et al, 2012). This observation implied that children may have had adequate intakes of zinc from diets. Differences in zinc levels between season, age and farming system could not be established as only one child was zinc deficient.

Soil transmitted Helminths

One child during plenty season presented with a light infection of hookworm. The parents of the child were paid a visit and encouraged to take the child to the clinic for consultation. Hookworm especially *A. duodenal* is considered a more pathogenic of the two hookworm species. It can gradually sap the individual's energy until they are lethargic (Ghodeif & Jain, 2019).

This has a negative bearing on the academic performance of the child. Current study results which barely showed presence of STH amongst study children differed with other studies (Francis et al, 2012, Tchinda et al, 2012, Debalke et al, 2013). The low prevalence of STH in this study could mean that the environments in the study areas were non-conducive to STH growth.

Other parasitic infestations

Three types of intestinal parasites that were prevalent in the study children as compared to STH during both seasons included *Diphyllobothrium latum*, *Hymenolepis nana* and *Hymenolepis diminuta*. Discussions on individual parasites are as follows:

Diphyllobothrium latum, the fish tapeworm, is the biggest tapeworm in humans causing an infection called diphyllobothriasis which is acquired by eating raw fish infected with the parasite. Diphyllobothriasis is usually asymptomatic. In some cases, it causes severe vitamin B_{12} deficiency because *D. latum* can absorb most of the vitamin B_{12}. In some cases, it can lead to neurological symptoms. Diphyllobothriasis symptoms include: constipation, diarrhea, fatigue, and obstruction of the bowel, pernicious anemia (caused by vitamin B_{12} deficiency) which can lead to degeneration of spinal cord, stomach pain and vomiting and weight loss. Migrating proglottids can cause inflammation of the bile duct or the gall bladder (Shafaghi et al, 2015).

Infestation with the tapeworm parasite is consistent with consumption of raw fish in children of school age in other countries (Lee et al, 2015). Children infected with this parasite may present with anemia, underweight and even miss school due to illness.

Hymenolepis nana, the dwarf tapeworm, is the most common cestode parasite of humans in the world (Shahnazi et al, 2019). It can be found wherever humans and rodents live. It absorbs nutrients from the intestinal lumen (Yanola et al, 2018). In children, high infection loads can be dangerous. Usually it is the larva of this tapeworm that causes the most problem in children. The larvae absorb all the nutrition from the food the child eats (Amare et al, 2013).

Usually a single tapeworm will not cause any danger, but in small children, many tapeworms can become a problem. *Hymenolepis nana* usually will not cause deaths unless in extreme circumstances and usually in young children or in people who have weakened immune systems.

Hymenolepis diminuta is a cestode which sometimes causes infection in humans. Human infection results from eating such foods as dried fruits and precooked breakfast cereals in which the infected grain insects, themselves infected from eating rat or mouse droppings, are present.

Some symptoms of infestation in humans include enteritis, anorexia, headaches, anal pruritus, abdominal distress and small gut irritation (Gupta et al, 2016). Hymenolepiasis is the term used for humans who are infected with either *H. diminuta* and/or *H. nana*, *H. nan*a is a dwarf sister specie very closely related to *H. diminuta*. Results obtained in this study are consistent with work conducted elsewhere (Nguyen et al, 2012; Mutungi et al, 2019).

Thus far, the only study on parasitic infections conducted in Botswana goes back to 1996 (MoH, 1996). This study found a prevalence of 38% parasitic infestations in the under-fives. Parasites identified included G. lambia (52%), H. nana (27%) and hookworm (15%). Comparing these results to those of the current study, the study SAC seemed to have better health status. Deworming campaign that occurred around 2007 could have had an impact, hence the low prevalence (UNICEF, 2013b).

Relationship between STH and iron status

The objective could not be answered due to lack of sufficient data on STH.

Underlying Determinants

The final lap of the discussion falls on the underlying factors, which focusses on household food insecurity, care for caregiver and child and health environment and services around the child. These are discussed as follows:

Household food insecurity

In order to understand the child's dietary intake, where they live cannot be underlooked. When assessing household food insecurity where the study children resided whether by season, caregiver age group and/or farming system, it was demonstrated that food insecurity was a problem with over 88% of households being food insecure. This was more than the national rural food insecurity rate of 50.2%. (Statistics Botswana, 2018) showing the vulnerability of the farming communities in the study areas. Only a small proportion in both seasons (4.4% in lean and 11.3% in plenty) were food secure.

Households experienced food insecurity as indicated by increased worry over household food supply, intake of food of compromised quality and poor intake of food in general. The worst condition of going whole day and night without food was common and experienced by over 26% of households. No more than 10% of households experienced this severe food insecurity condition often (>10 times) in the past 30 days prior to interview. These results were in agreement with previous work in the country showing only 2% of households in the Upper Panhandle, Okavango Delta to be food secure.

This meant that the rest presented with mild to moderate food insecurity (Ngwenya and Nnyepi, 2011). Other works done on household food insecurity elsewhere are in agreement with this study results that as households become more food insecure, coping strategies are put in place such as eating less, skipping meals, consuming low quality food and sometimes sleeping or going whole day without food (Ngwenya and Nnyepi, 2011; Nnakwe and Onyemaobi, 2013, Belachew et al, 2013).

Evidence also shows that rural households and especially those with children are likely to be more food insecure (Nnakwe and Onyemaobi, 2013) probably because of limited resources and food that is unable to meet the nutrient needs of the growing child (Belachew et al, 2013). It was also noted that irrespective of season, age and/or farming system, households of older caregivers over 35 years struggled more with food insecurity. This could be because the majority of older caregivers have primary source of livelihood as farming. Therefore if faced with shocks such as flooding which adversely affects crop yield, they may have no other alternative of recovering.

Household food insecurity plays a negative role in the nutrient intake, growth and quality of life of child; hence, it is important to address it early. Food insecurity results in inability to meet nutrient needs of the children which may indirectly cause stunting and or inhibit catch-up growth in the child who had been stunted (Belachew et al, 2013).

Differences of household food security when compared by season, age and farming system

Using the HFIAS there was no significant difference in household food insecurity when comparing HFIAS by season, age and/or farming system. Additionally, the lack of difference in the households by season, age and/or farming type indicated similar struggles being experienced by all farming households. From observation and being in the field, the study period from 2010 to about early 2012 was characterized by high flood flows and then thereafter till about 2013 there was small to no inundation (National Hydrological Services Botswana, 2013) resulting in less optimal conditions for both flood recession and rain-fed farming. This had a negative bearing on food availability. It also implied that during the study periods, households had to resort to other means of procuring food, whether through purchasing and/ or receiving food aid.

Households irrespective of farming system may be cushioning one another through the sharing and/or battering system. Being aware of each other's challenges community members irrespective of farming system may be lending assistance one to another accordingly.

One factor, household income was statistically significant in influencing household food insecuriyt. With every unit increase in household income, households were likely to have reduced food security by 24%. With the study areas being in the rural areas, even if near peri-urban areas like Gumare for Tubu and Maun for Shorobe, the amount of income households make cannot be substantial nor can it contribute to improving agricultural productivity.

Communities there survive through sales of natural resources such as basket weaving, reeds and/or work in government poverty alleviation schemes like Ipelegeng which are meagrely rewarding. This means that even when household income may improve, there are still limitations like lack of supermarkets and wholesales that can provide diversity in terms of food stocks. Poor infrastructures like gravel roads and lack of transport may also make commuting to the nearby peri-urban areas difficult for the purchasing of food stuffs.

Furthermore, since most of these study areas have tuck shops, price hikes further add to the problem by limiting what can be purchased to create a huge shift in household food security, hence having adequate income doesn't always improve household food security (Hirvonen et al, 2015; Herrador et al, 2015).

Caregiver and child care and health environment and services

Child care is described through caregiver empowerment level with either education or resources to be able to take care of the child. Caregiver attributes like age, education, marital status, occupation and caregiver relation to child suggest the ability of the caregivers to take care of the children. These variables were inspired by evidence suggesting that when a caregiver is experienced with child care, has knowledge and the right support whether income or relationship-wise, they are able to make decisions that can favour the health of the child (Emamian et al, 2013; Ickes et al, 2015; Assefa et al, 2015). However, none of the factors entered into the binary modelling were found significant to influence child care and health environment and services.

CHAPTER 6 CONCLUSION

Undernutrition characterized by underweight, thinness and anemia were public health concerns identified in the study children. Underweight was more common in the younger children below 10 years whereas thinness was more so in the older children aged 10 years and above. The severity of thinness (prevalence between 9% and almost 19% in the plenty and lean season respectively meeting the WHO classification of high to very high) in SAC children warrants immediate attention throughout the year. Although underweight may signify cumulative and recent periods of not eating well and/or illness, the fact that wasting levels were higher than stunting levels associated with chronic malnutrition was a sign that undernutrition in the study was a result of acute causes such as poor dietary intake. Slight improvement of these conditions over the plenty season further proved that undernutrition was from acute causes. Interventions on thinness should be targeted to all SAC irrespective of age. Additionally, the problem of household food insecurity might have further increased the problem of undernutrition. The evidence of polyparasitism indicating a problem with poor- hygiene, food handling and preparation and sanitation further adds to worries that children in addition to being poorly fed may have faced health challenges that also contributed to the increase in acute malnutrition (Uneke, 2010).

Meals of the study children seem monotonous saturated with energy dense foods. There is less representation of nutrient dense foods such as fruits, vegetables, fish and eggs among others in the children’s diets. Meal patterns of the SAC were negatively influenced by lean season, household income sufficiency and being from Tubu village whereas *molapo* farming positively influenced them.

All households from the two farming types may benefit from similar interventions, addressing issues such as predictability and monitoring of floods, using indigenous foods to augment current meal patterns, protein foods diversification, food combinations for optimal nutrient absorption and healthy eating amongst others.

Interventions should be tailored according to seasons, village, farming system. All these factors have an undertone and/or influence from climate change. Since the study showed that despite challenges from the unreliable ecosystem the plenty season as compared to the lean season and *molapo* farming seemed to decrease the likelihood of the children being undernourished, the communities may therefore benefit from food preservation during the plenty season to be used during lean times. This way children's and households' nutritional status would not be compromised.

Furthermore, the farming system of *molapo* should be invested on because irrespective of challenges incurred in it there seem to be overall benefits in improving dietary diversity which eventually may affect the nutritional status of the children and community in general. *Molapo* is a promising farming system that may feed not only *molapo* households but the nation at large if precautionary care is taken. Although anemia was a public health concern amongst study children, zinc deficiency was not. Similarly, STH was not a problem of public health significance among study children whether compared by season, age and/or farming system.

Households in which the study children resided were plagued with food insecurity irrespective of season, age and/or farming system. This may negatively affect the children through inability to meet required nutrient needs, poor development and growth status, adoption of poor eating habits and inability to reach catch-up growth. Food insecurity interventions and strategies should be inclusive of all members of the community as food insecurity is all encompassing in these study areas.

Many of the results on factors responsible for poor nutritional status were not expected. However, a possible explanation to these unexpected findings could be climatic challenges faced by the community in the study areas at the time of the survey. Variability in flood distribution may exert strong influence on the livelihood of the dependent communities resulting in crop damage. Too high and/or too low moisture affect plant growth processes. Excess moisture leads to inability of plant to stand upright and may also lead to delayed flowering whereas lower moisture content lead to delayed germination (Kolawole et al, 2016; Bosekeng et al, 2017). The damage of crops by differing moisture levels may end up compromising food availability and consequently nutritional status.

CHAPTER 7 RECOMMENDATIONS

Since SAC spend most of their time at school it is advisable that the government further revise the school feeding program to ensure continual provision of food in schools by suppliers. Furthermore, those delegated with responsibility to prepare school foods must be empowered with knowledge of how to prepare meals for SAC to ensure optimal dietary intake and absorption. This may therefore call for the involvement of more learned people such as Nutritionist and Dieticians who understand the concept of healthy eating. Similarly, caregivers must also be empowered with similar knowledge and training of how to ensure optimal dietary intake and nutrient absorption in the children's meals.

It is also recommended that the gardening in primary schools be reintroduced. This program may put back food on the plates of the children and help solve the problem of poor dietary diversity and intake, micronutrient deficiencies and malnutrition. Children may also show more interest in the consumption of such foods as vegetables since they would have been involved in producing them.

Seasonality is an important factor in the influence of underweight. Although seasonality (plenty season) seems to be less likely to perpetuate underweight in children, the effect of unpredictable climatic conditions affecting farming in the study areas cannot be overlooked. Consequently, it is suggested that meteorological services work with the rural farming communities to use both indigenous knowledge systems and technological systems to predict and monitor floods or flows. This may be assistive in informing farmers in advance of what to expect and what actions to take.

Furthermore, farmers should have livelihood diversification strategies in place to help them cope with any shortcomings resulting from either too much flooding, no flow and/or drought years and or less than expected harvests (Motsholapheko et al, 2012).

Additionally, since underweight was common during lean times and not so much when there was plenty food, there should be a focus on food preservation during seasons of plenty to ensure flow of food even in to the lean seasons. This in turn would safeguard both adult and child household members’ nutrition and health status.

Despite the government of Botswana’s commitment to assist in the alleviation of hunger and malnutrition in her children, the medium to high prevalence of thinness is indicative of the acute insufficiency of food intake by SAC. Therefore, care for this age group is highly recommended both in the school and home setting. Interventions proposed should focus on acute malnutrition eradication. The objectives of proposed interventions should be to improve dietary intake and to educate the caregivers, SAC and the general household on good food handling and preparation practices as well as good hygiene and sanitation practices. Although the study has shown persisting household food insecurity that may probably hinder some caregivers to provide enough food for the children, it is critical that the use of natural resources such as wild fruits, tubers and roots available in the surroundings be encouraged to augment and improve children’s dietary intake and nutritional status. Partnership of caregivers with the government in the improvement of the children’s health and nutritional status is highly encouraged.

The idea of having joint collaboration between meteorological services and rural farming communities to use both indigenous knowledge systems and technological systems to predict and monitor floods or flows resurfaces here again. The information is critical to informing farmers in advance of what to expect and what actions to take. Also as much as the communities seem to live lifestyles not so dependent on purchasing power, it is still necessary that communities engage in extra livelihood diversification strategies to assist in coping with any shortcomings resulting from the unreliable ecosystem (Motsholapheko et al, 2012).

It follows logic to concentrate on the education about the improvement of diets of the SAC. The education should cover modules on balanced diets and requirements for the school age lifecycle. Children should also be introduced to diverse indigenous and wild foods that can augment existing diets. Work has been done to identify, prepare and feed different indigenous dishes to a group of primary school children in the study areas. These children demonstrated acceptance of the dishes and indicated that if parents prepared them, they would eat them (Nnyepi et al, unpublished). In a participatory rural appraisal meeting in the Project study areas, community members from Xobe settlement in Ngamiland reported that they never experienced malnutrition in children because they harvested wild foods and prepared healthy nutrient dense meals for children (Botswana Ecohealth Project, 2010 unpublished). It is therefore essential that both caregivers and SAC be educated on the importance of the edible natural resources in surrounding areas and how they can be used to curb the problem of anemia and malnutrition in general. This type of education can also be incorporated to the school syllabus so SAC learn it from a tender age. Additionally, interventions to improve dietary diversity should be tailored according to farming systems, season and village to ensure that appropriate and relevant interventions and solutions that work are put in place.

Since caregivers are primary caretakers of the children, they should thus be educated on inhibitory factors of nutrients like zinc so as to optimize and maximize absorption in children. This will help to keep zinc deficiency at low levels and/or help maintain and/or completely do away with current prevalence. Despite one child being affected, education to both caregivers and SAC on the dangers and causes of STH and effect on wellbeing is necessary to curb the problem from spreading.

The presence of intestinal helminths is of major concern as these are treated as neglected tropical diseases. Given the above, de-worming of school children by the health authorities is of paramount importance in curbing the widespread of the intestinal helminthic infections that could have some debilitating effects on the school children's general performance levels. Additionally, education among both caregivers and children on these neglected tropical diseases is essential for curbing the widespread.

Household livelihood diversification strategies such as keeping small livestock, engaging in small backyard gardens in addition to farming and sales of farm and natural resources may be helpful in preventing severe food insecurity and preserving the quality of life of the children. Schools can also assist in improving the health of children by encouraging garden farming which can feed the children and add diversity to school meals. Finally, it may be time to seriously invest in *molapo* farming system which is promising to improve dietary diversity of not only the study children and communities but could be used to benefit the country at large.

Limitations of the Study

Few factors limit this study results from being generalized amongst SAC (6 to 13 years) in farming communities. For instance, the study used a smaller sample size to assess nutritional status of children at both study points. This limited statistical power. The other limitation was the unfortunate loss of blood sample by the service provider. However the study results rely greatly on the well-articulated sample design and planning of the study.

Future Research

The researcher suggests a similar study but looking at a bigger sample size to assess the nutritional status of SAC in Botswana. Furthermore, the researcher suggests use of latest tecnologies such as use of deuterium Oxide to measure the growth status of children.

Implication of study results

Although sample size was a major limitation in the study and it’s advisable to use these results with caution, results can be informative on three levels. These include SAC level, rural and farming community level and national level. The implication on these levels is as follows:

- SAC level: Like under-fives, this age group should equally be paid attention to ensure optimal growth

- Farming community level: 1) The SAC is the project of both the parents and the government. Therefore, collaboration between two entities is highly encouraged 2) Education on proper child care is needed in households. The education modules should include topics such as good sanitation and hygiene practices and good food handling and preparation practices and 3) Innovative ideas such as smart and flood resistant farming are encouraged. For instance ploughing on a hilly surface and/or raised beds to avoid plants and/or vegetable submission in flood water which can ruin the yield is important.

  Flood water can be used to irrigate these gardens and 4) Communities must be encouraged to have extra livelihood diversification strategies to cope with household insecurities

- National level: 1) School Health Policy and School Health Program Implementation Strategy should be revised to allow annual assessments to track SAC health. Implementation of the policy and program should be emphasized. Moreover, assessments should target to include growth status assessments to ensure easy tracking of SAC nutritional status in Botswana

  2) School Feeding Policy-it ought to be revised especially in rural farming areas where they are usually affected by different natural shocks such as floods to address acute malnutrition and household food insecurity. The daily caloric intake could possibly be raised to 50% instead of 30% 3). The appropriate Ministry possibly Ministry of Local Government and Rural Development, should ensure continual supply of foods to schools 4) collaboration of government and local farming communities towards flood prediction and monitoring

5) Programs such as Destitute Persons Program, Vulnerable group Feeding Program and Remote Area Development Program must collaborate during troubled times to help those households that are hardly hit 6) Poverty eradication programs like Ipelegeng should be revised to give priority to older caregivers who seem to suffer more from household food insecurity so that they can sustain themselves from the hardship 7) National malnutrition status update is long overdue to give an appropriate picture in the country and

8) The government of Botswana through its financial aiding institutions should invest in *molapo* farming system because of its promising capacity to improve food availability and dietary diversity irrespective of challenges

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APPENDICES

Appendix 1

Seasonal calendar of events drawn by communities in study areas

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	NOW	Dec
Rains												
Floods												
Ploughing												
Land preparation												
Letlhafula/Harvest												

Appendix 2

Table 39 Normality test results for numeric data used in the study

PARAMETER	TEST OF NORMALITY	SAMPLE SIZE	*p*-value	NORMALITY DECISION	Suggested statistical test
Lean season					
Objective 1					
HAZ	Shapiro-Wilk	134	0.981	Normally distributed	t-test
WAZ	Shapiro-Wilk	134	0.303	Normally distributed	t-test
BAZ	Shapiro-Wilk	134	0.002	Not normally distributed	Wilcoxon rank sum test (Mann-Whitney)
Objective 2					
Hemoglobin	Shapiro-Wilk	53	0.125	Normally distributed	t-test
Zinc	Shapiro-Wilk	54	0.533	Normally distributed	t-test
Ferritin	Shapiro-Wilk	0	N/A	N/A	
Plenty Season					
Objective 1					

PARAMETER	TEST OF NORMALITY	SAMPLE SIZE	*p*-value	NORMALITY DECISION	Suggested statistical test
HAZ	Shapiro-Wilk	84	0.796	Normally distributed	t-test
WAZ	Shapiro-Wilk	84	0.018	Not normally distributed	Wilcoxon rank sum test (Mann-Whitney)
BAZ	Shapiro-Wilk	84	0.005	Not normally distributed	Wilcoxon rank sum test (Mann-Whitney)
Objective 2					
Hemoglobin	Shapiro-Wilk	23	.000	Not normally distributed	Wilcoxon rank sum test (Mann-Whitney)
Zinc	Shapiro-Wilk	36	0.604	Normally distributed	t-test
Ferritin	Shapiro-Wilk	37	0.147	Normally distributed	t-test

Appendix 3

Application for Approval of Human Research

Ministry of Health

Republic of Botswana

Application for ApprOWal of Human Research

<u>Section A: Instructions</u>

1. ***For research/academic institutions or PHD students attach:***
   a) ***<u>14 copies</u> of the Research Application form***
   b) ***<u>4 copies</u> of the following:***
      i. ***Study proposal.***
      ii. ***Consent/authorization form or a request for waiver of consent/authorization- Setswana, English and back translation where applicable.***
      iii. ***Questionnaires to be used. Setswana, English and back translation where applicable.***
      iv. ***Curriculum vitae/ resume of <u>each</u> member of the Research team***
      v. ***ApprOWal letter from other IRBs***
      vi. ***Grant apprOWal letter***
      vii. ***Any other supporting materials i.e. recruitment scripts, brochures, flyers etc***

2. For undergraduates and graduates attach one copy of the above listed items/ documents.

Section B: Application Details

1. Study Title: (Include Version number and date) Nutritional status of children in Tubu, Xobe and Shorobe *molapo* farming households, Ngamiland, Botswana
2. Date of submission: *12 August 2011*
3. Type of Research: **i. Basic Science ( )** **ii. Public Health (√)** **iii. Clinical Research ( )** **iv. Human Biology ( )** **v. Other________________________**

4. Principal Investigator*(Name & Qualifications)*: *Prof M.J. Chimbari (PhD)*	**4(i). Local Contact Details** ***Name:*** *Prof M.J. Chimbari, University of Botswana, HOORC*

Postal Address: *University of Botswana, ORI, P. Bag 285, Maun, Botswana*	**Postal Address:** *University of Botswana, ORI, P. Bag 285, Maun, Botswana*
Phone Number: *267 681 7239*	**Phone Number:** *267 681 7239*
E mail Address: *mchimbari@orc.ub.bw or mjchimbari@gmail.com*	**E mail Address:** *mchimbari@orc.ub.bw or mjchimbari@gmail.com*
Name of affiliate Institution/Organization: *University of Botswana*	**Name of Institution/Organization:** *Okavango Research Institute (ORI)*
Department *(If Government)*:	**Department *(If Government)*:**

5. Other Investigators /Co-Principal Investigators			
Name:	**Organization:**	**Email:**	**Telephone Number:**

6. Key Personnel working with data that may be linked to human subjects:			
Name:	**Organization:**	**Email:**	**Telephone Number:**
Galase Ramolefhe	*Okavango Research Institute/UB*	*gramolefhe@orc.ub.bw or galase.ramolefhe@bastyr.edu*	*+267 681 7201*
Elijah Chirebvu	*Okavango Research Institute*	*Echirebvu@orc.ub.bw*	*+267 681 7201*

Section C: Description of Research

4. Expected Results ***(Both Primary and Secondary endpoints)*****:**
.

Section D. Methodology

1. Study Design
1. Inclusion Criteria
2. Exclusion Criteria:
3. Does the study involve Vulnerable Groups? *(Tick all that Apply)*? **Elderly** ( ) **Children** (√) **Pregnant women, fetuses, or neonates of uncertain viability or nonviable** ( ) **Prisoners** ( ) **Decisionally impaired Persons** ( ) **Minority and indigenous groups** ( ) **Low Literacy** ( ) **Economically Disadvantaged** ( ) **Other**______________________________ **N/A** ( )

4. Does this study involve any use of a drug? No (√) Yes ( ). If yes, is the drug registered or given exemption status (IND studies) by the Drug Regulatory Unit in Botswana? *If yes attach proof)*   ___ _______________________
5. Reasonably foreseeable risk or discomforts to the subjects (*list in detail)*:   Dizziness may occur from blood drawing hence children will be given a juice and bread immediately after blood draws and will be encouraged to take a sit.
6. Who will cOver Subject Injury-Related Costs?   **i. Sponsor ( )**   **ii. Third-Party Payers ( )**   **iii. Subjects ( )**   **iv. N/A (√)**   **v. Other ____________________________**
8. Give details of Botswana based personnel that will be involved *(Name, functions and qualifications)*:

9. Any remuneration given to subjects? Yes ( ) No (√). If yes, specify:
10. Will the participant incur any financial cost in this study? Yes ( ) No (√). If yes, specify:

Section F: Data Sources

1. Sources of Data

i. **Focus Group(s)** (√)

ii. **Interviews** (√)

iii. **Questionnaires/Surveys** (√)

iv. **Census/Public Records** ( )

v. **Human Biological Specimen**

( ) Archive (√) Prospectively Collected (√) Discharged ( ) Stored Samples

vi. **Medical Records** ( )

vii. **Registers *(e.g. TB register and Cancer register)*** ( )

viii. **Other _____**health facility petients attendance register

____

Section G. Study Details

3. Other Ethical Body(ies) Involved in the review of the study
Institutional Review Board for University of Botswana

Section H: Sponsor Information

1. Name of Sponsor: Botswana Ecohealth Project (BEP) through International Development Research Centre (IDRC), Canada Office of Research and Development (ORD)/UNICEF, University of Botswana,

____

2. Type of Sponsor:

i. **Government** ( )

ii. **Private Foundation** (√)

iii. **Industry** ( )

iv. **Internal** ( )

v. **Other** (√)

3. Sponsor Contact Person: Professor Chimbari (BEP). Mr C. Matasane, Office of Research and Development (ORD) University of Botswana/UNICEF

____

4. Sponsor Contact

Telephone:

___3552903____

<u>Section I: Contact Information</u>:

PI or other researchers for answers to questions about the study or research-related injuries*(You must offer at least two contacts)*:	**The HRDC representative who can answer questions about their rights as research subjects**
i). Prof M. J. Chimbari, HOORC, P. Bag 285, Maun. Phone 267 6817239 Fax 267 6861835 **ii) Galase Ramolefhe, ORI, P/Bag 285, Maun. Phone 267 6817201**	**Name____________________________** **Head of Health Research Unit** **Ministry of Health** **Private Bag 0038** **Botswana** **Tel: (+267) 3914467** **Fax: (+267) 3914697**

iii) Elijah Chirebvu, ORI, P/Bag 285, **Maun. Phone 267 6817201**	

Section J: Investigator's Statement

INVESTIGATOR'S STATEMENT OF ASSURANCE **I promise to abide with existing relevant International Declarations and National procedures and guidelines when undertaking research involving human subjects within the Republic of Botswana and agree to:** **1. Ensure that all studies conducted on human participants are designed and conducted according to sound scientific and ethical standards within the framework of good clinical practice.** **2. Report to the Health Research and Development Committee any information requested, serious or unexpected adverse events and any information related to national programs.**

3. Unless if an emergency treatment for patient care, obtain prior apprOWal from the HRDC before amending or altering the scope of the project or implementing changes in the apprOWed consent form(s).

4. Submit progress reports as required by the HRDC.

5. Maintain all documentation including consent forms and progress reports.

6. Ensure that all members of the research team are aware of their roles and responsibilities in this study.

7. Ensuring, in accordance with the duties outlined for each member, that all members of the team are fully utilized for tasks assigned to them.

Principal Investigator's Name: Prof M.J.Chimbari

Principal investigator's Signature: **Date:19**/08/11

Principal Investigator's Position: Deputy Director

Local Investigator's Name: Prof M.J. Chimbari

Local investigator's Signature: **Date:**28/05/09

Local Investigator's Position: Deputy Director

After Completion

1. **An electronic and hard copy of the report should be submitted to the Health Research Unit, Ministry of Health as well as other relevant Botswana Government Institutions/Organizations within 3 months of producing a bound report.**

2. **All continuing renewals should be submitted at least 6 weeks before the expiration.**

Section K. For Health Research Unit use ONLY.

1. Date Received	**6. Review Body [ ] Health Research Unit [ ] HRDC**
2. Final Outcome	
3. Ref No:	
4. Expiration Date:	
7. Continuing renewals extension	

Date 1 ____ **Date 2 ____** **Date 3 ____**
8. Final Report Submission **( ) Yes** **Date _______________________** **( ) No**

Appendix 4

Informed Consent Form

For Parental Consent

NUTRITIONAL STATUS OF CHILDREN IN TUBU AND SHOROBE *MOLAPO* FARMING HOUSEHOLDS, NGAMILAND, BOTSWANA

Principal Investigator: Dr. L. Magole (PhD)

Co-Investigator: Galase Ramolefhe (MSN)

Phone number (s): (267) 681 7227; (267) 681 7201

What you should know about this research study:

- We give you this consent so that you may read about the purpose, risks, and benefits of this research study.
- Routine care is based upon the best known treatment and is prOWided with the main goal of helping the individual patient. The main goal of research studies is to gain knowledge that may help future patients.
- We cannot promise that this research will benefit your child. Just like regular care, this research can have side effects that can be serious or minor.
- You have the right to refuse to allow your child to take part, or agree for your child to take part now and change your mind later.
- Whatever you decide, it will not affect your child’s regular care.

- Please review this consent from carefully. Ask any questions before you make a decision.
- Your choice to allow your child to participate is voluntary

PURPOSE

You are being asked to allow your child to participate in a research study that seeks to assess nutritional status of children (6 to 13years) in *molapo* farming households of Tubu and Shorobe. Nutritional status will be assessed using indicators of anthropometric measurements (weight, height and MUAC), dietary intake, serum iron and zinc status and prevalence of soil transmitted helminths infestations. Your child was selected as a possible participant in this study because she lives in one of *molapo* farming households. Your child will be one of the 210 children required for the study

PROCEDURES AND DURATION

If you decide to allow your child to participate, your child will be requested to donate blood and stool specimen four times during the one year period of the study.

RISKS AND DISCOMFORTS

Drawing blood from children may cause dizziness. To control this children will be given a slice of bread and juice immediately after blood draw and will be encouraged to have a sit.

BENEFITS AND/COMPENSATION

The community and the children will benefit from the study. At the end of the study the community will be knowledgeable on the nutritional status of children in *molapo* and *non-molapo* farming households. They will also know the food security status of households in these farming types. Moreover, they will be knowledgeable on iron and zinc status and on the prevalence of soil transmitted helminths and how these can contribute to poor nutritional status of the child.

CONFIDENTIALITY

If you indicate your willingness for your child to participate in this study by signing this document, then the nutritional status of your child will be known by many stakeholders such as Ministry of Health, Ministry of Education, UNICEF, University of Botswana, and Okavango Research Institute, local authorities of Tubu and Shorobe, and yourself. No information related to your child will be passed on to anyone else without your, and when appropriate, your child's permission.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you decide not to allow your child to participate in this study, your decision will not affect you or your child's future relation with the study team and the University of Botswana. If you decide to allow your child to participate, you and your child are free to withdraw your consent and assent and discontinue participation at any time without penalty.

OFFER TO ANSWER QUESTIONS

Before you sign this form, please ask any questions on any aspect of this study that is unclear to you. You may take as much time as necessary to think it over.

AUTHORIZATION

YOU ARE MAKING A DECISION WHETHER OR NOT TO ALLOW YOUR CHILD TO PARTICIPATE IN THIS STUDY. YOUR SIGNATURE INDICATES THAT YOU HAVE READ AND UNDERSTOOD THE INFORMATION PROWIDED ABOVE, HAVE HAD ALL YOUR QUESTIONS ANSWERED, AND HAVE DECIDED TO ALLOW YOUR CHILD TO PARTICIPATE.

The date you sign this document to enrol your child in this study, that is, today's date, MUST fall between the dates indicated on the apprOWal stamp affixed to each page, these dates indicate that this form is valid when you enrol your child in the study but do not reflect how long your child may participate in the study. Each page of this Informed Consent Form is stamped with the University of Botswana stamp to indicate the form's validity.

Name of Parent (please print) Date

Signature of Parent or legally authorized representative Time AM/PM

Relationship to the Subject

________________________________ ________________________________

Signature of Witness (optional) Signature of Research Staff

My participation in this research study is voluntary. I have read and understood the above information, asked any questions which I may have and have agreed to participate. I will be given a copy of this form to keep.

Name of Subject

____

Signature of Subject

YOU WILL BE GIVEN A COPY OF THIS CONSENT FORM TO KEEP.

If you any questions concerning this study or consent form beyond those answered by the investigator including questions about the research, your rights as a research subject or research-related injuries; or if you feel that you have been treated unfairly and would like to talk to someone other than a member of the research team, please feel free to contact the Director of Okavango Research Institute (ORI) on +267 681 7222.

Appendix 5

Tumalano E E Direlwang Mo Kitsong

Tetla Ya Motsadi

TSHEKATSHEKO YA SEEMO SA DIKOTLA MO BANENG (6 to 13) BA MALWAPA A TEMO YA *MOLAPO* MO TUBU LE SHOROBE, NGAMILAND, BOTSWANA

Mokanoki mogolo: Dr. L. Magole (PhD)

Bakanoki ba bangwe: Galase Ramolefhe (MSN), Nnyepi M. (PhD) le Ama N. O (PhD)

Dinomore tsa Megala: (267) 681 7227; (267) 681 7201

Se o tshwanetseng go se itse ka thuto tsheka tsheko e:

- Re go neela mokwalo tetlelelo o gore o itse maikaelelo, bodiphatsa le dipoelo tsa tsheka tsheko ya dithuto.
- Tlhokomelo ya nako le nako e dirwa go remeletswe mo kalafing e e tshwanetseng, ee itseweng, e bile e diragadiwa go ikaeletswe go thusa molwetse. Maikaelelo a magolo a ditsheka-tsheko tsa dithuto ke go nna le kitso e e ka solegelang balwetse mosola mo nakong e e tlang.
- Ga re ka k era solofetsa fa dipatlisiso tse di tla solegela ngwana wag ago mosola. Fela jaaka tlhokomelo ya botsogo ya nako le nako, dipatlisiso tse di ka nna le ditla-morago tse di tona kgotsa tse di nnye.

- O na le tshwanelo ya go gana gore ngwana wa gago a tseye karolo mo dipatlisisong tse, kgotsa o ka dumalana le gore a tseye karolo mo nakong eno mme wa felela o fetola tshwetso ya gago moragonyana.
- Tshwetso efe fela e o e tsayang, ga e kitla e ama tlhokomelo ya botsogo ja ngwana wa gago ka tsela epe.
- Ka tswee-tswee, seka seka mokwalo-tetla ka kelo tlhoko. Botsa dipotso tse o nang le tsone pele gao ka tsaya tshwetso.
- Tshwetso ya go letlelela ngwana wa gago go tsaya karolo mo dipatlisisong tse ke ya boithaupi fela.

MAIKAELELO

O kopiwa go ntsha tetla ya gore ngwana wa gago a tseye karolo mo tsheka-tshekong e ya seemo sa dikotla sa bana (dingwaga tse 6 to 13) mo malwapeng a temo ya *molapo*. Maikaelelo a thuto-dipatlisiso tse, ke go kanoka seemo sa dikotla sa bana ka go lebelela kgolo, dikotla (iron le zinc), seemo sa dijo mo malwapeng, mekgwa ya go jag a bana, le malwetse a mala mo baneng a a ka tswang a bakwa ke go tshamekela mo mmung. Ngwana wa gago o tlhophilwe e le mongwe yo o ka tsayang karolo mo dipatlisisong tse ka o tswa mo lelwapeng le go lengwang temo ya *molapo*. Ngwana wa gago o tlaabo a le mongwe wa ba ba makgolo a mabedi le lesome (210) ba ba tla tsayang karolo mo thuto-patlisisong e.

TSAMAISO LE LOBAKA LA TSHEKA-TSHEKO

Fa o naa tetla ya gore ngwana wa gago a tseye karolo mo tsheka-tshekong e, itse fa a ka nna a nna mongwe wa ba ba masome a marataro ba batla kopiwang go aba madi le mantle a bone gabedi mo ngwageng ya tshekatsheko.

BODIPHATSA LE GO TLHOKA BOIKETLO

Kabo ya madi e ka nna ya ira gore ngwana a tsewe ke sedidi mme ke ka moo re tla bong re ba ha borotho le seno ha ba sena go tsewa madi. Re tla bo re ba rotloetsa gape go nna fa fatshe sebakanyana go itsa go oketsa sididi.

DIPOELO LE DIKATSO

Ko phelelong ya thuto-patlisiso e, batho mo motseng le bana batla bona dipoelo. Batho mo metseng batla itse ka kgolo, seemo sa dikotla (iron le zinc) sa bana, seemo sa dijo mo malwapeng le mekgwa ya go ja ya bana. Batho ba tla itse gape ka seemo sa malwetse a mala a a tshabelelang bana a a rotloediwang ke go tshamekela mo mmung le ka tse tshotle di ka rotloetsang go tlhoka go gola sentle ga bana.

PABALESEGO YA KANAMISO YA SEEMO SA NGWANA WA GAGO

Fa o dumalana le gore ngwana wa gago a tseye karolo mo tsheka-tshekong e ka go baya monwana (go saena) mokwalo o, seemo sa botsogo sa ngwana wa gago se tla itsiwe fela ke makalana a Ministry of Health, Ministry of Education, UNICEF, University of Botswana, Okavango Research Institute, baeteledi pele ba metse ya Tubu le Shorobe, le wena fela. Ga gona sepe se se amanang le ngwana wa gago se se ka itsisiweng ope go sena tumalano ya gago, ga mmogo le ya ngwana wa gago, fa go tlhokafalang teng.

BOITHAUPI MO GO TSEYENG KAROLO

Go tsaya karolo mo tsheka-tshekong e ke ga boithaupi. Go tsaya tshwetso ya go sa tsaya karolo mo tshekatshekong e ga go kitla go ama wena kana ngwana wa gago ka tsela epe fela mo ditirisanyong tsa gago le setlhopa sa bakanoki, ga mmogo le University ya Botswana. Fa o letlelela ngwana wa gago go tsaya karolo, ngwana wa gago ga mmogo le wena lo gololesegile go boela morago tshwetso-tumalano ya lona lo bo lo tswa mo tsheka-tshekong ka nako efe fela, e bile ga go ke go nne kotlhao epe ya kgato ya lona.

KARABO YA DIPOTSO

Fa go na le sengwe se o sa se tlhaloganyeng sentle ka mokwalo o, ka tswee-tswee botsa potso efe fela pele ga o saena. O ka tsaya nako e o bonang e go simaetse go akanya ka tswetso e o batlang go e tsaya.

GO NTSHA TAOLO

O DIRA TSHWETSO YA GO LETLA KGOTSA GO SA LETLE NGWANA WA GAGO GO TSAYA KAROLO MO TSHEKA-TSHEKONG E. GO BAYA MONWANA (TSHAENO) GO SUPA GORE O BADILE MME GAPE O TLHALOGANTSE MOKWALO O, MME O DIRILE TSHWETSO YA GO LETLA NGWANA WA GAGO GO TSAYA KAROLO MO TSHEKA-TSHEKONG.

Letsatsi le o gatisang tumalano e go dumela gore ngwana wa gago a tseye karolo mo tshekatshekong e (letsatsi la gompieno), le tshwanetse gore le bo le wela mo malatsing a teseletso ya setempe se se mo pampiring nngwe le nngwe sa University ya Botswana. Kgwedi e e supilweng mo pampiring e ke sesupo sa gore mokwalo-pampiri o, o letleleletswe, mme ga e supe sebaka se ngwana wa gago a tlaa se tsayang mo tsheka-tshekong. Go supa gore mokwalo pampiri o o ka fa tsamaisong, nngwe le nngwe e na le setempe sa University ya Botswana.

____ ____________

Leina la motsadi (kwala mo go bonalang) Letsatsi/kgwedi

____ ____________

Monwana/tshaeno ya motsadi kgotsa motlhokomedi Nako (Moso AM/ Motshegare PM)

____

Kamano le ngwana wa mo tsaya karolo

______________________________ ____________________________

Monwana wa mosupi (ga go pateletsege) Monwana wa mokanoki

Go tsaya karolo mo tshekatshekong e ke ga boithaopi. Ke badile ebile ke tlhalogantse mokwalo o o fa godimo, ke boditse dipotso tse ke ka tswang ke ne ke na le tsone, mme ke dumelane go tsaya karolo. Ke tla neelwa moriti wa pampiri-mokwalo o gore ke nne le one.

Leina la mo tsaya karolo

____

Monwana/Tshaeno

O TLAA NEELWA MORITI WA MOKWALO O GO O IPEELA

Fa o na le dipotso ka tsheka-tsheko e, mokwalo tumalano o o sa tswang go o bala, go feta tse di arabilweng ke mokanoki, go akarediwa ditshwanelo tsa gago o le motsaya karolo kgotsa dikgobalo dife fela tse di ka tswang di amana le tsheka-tsheko; kgotsa fa e le gore o tsaya gore o ka tswa o sa tsewa sentle fela ka tsela nngwe mme e bile o batla go bua le mongwe ko ntleng ga setlhopha sa bakanoki, ka tswee tswee gololesega go itshwaraganya le mookamedi ko Okavango Research Institute (ORI) mo mogaleng wa +267 681 7222.

Appendix 6

CHILD PARTICIPANT ASSENT FORM

NUTRITIONAL STATUS OF PRIMARY SCHOOL CHILDREN (6 to 13 YEARS) IN TUBU AND SHOROBE FARMING HOUSEHOLDS, NGAMILAND, BOTSWANA

Principal Investigator: Prof. Moses John Chimbari (PhD)

Co-Investigator: Galase Ramolefhe (MSN)

Phone number (s): (267) 681 7239; (267) 681 7201

We want to tell you about a research study we are doing. A research study is a special way to find out about something. We are trying to find out more about your nutritional status. You are being asked to join the study because you are within the study population of primary school going children and belong to a family that practices farming.

If you decide that you want to be in this study, this is what will happen. You will be requested to donate blood and stools, answer questions about your eating habits and allow us to take your weight and height measurements twice within a 1year duration of the study. Our doctor who is taking your blood using a clean needle will take it from your arm. We will take about a tablespoon, which is important to find out if you have enough nutrients to help you grow. For stool sampling we will give you a small container where you can put about a teaspoon of your stool, which is necessary to check for any worms that may make you sick. You will go into the toilet by yourself to ensure privacy.

Can anything bad happen to me?

We want to tell you about some things that might hurt or upset you if you are in this study. The needle we use to take the blood may hurt. You might get a bruise on your arm. You may also feel dizzy after your blood is drawn. However, we will encourage you to have a seat and enjoy a slice of bread and juice immediately after blood draw to lessen the dizziness. An experienced doctor will take your blood so that it doesn't hurt much.

Can anything good happen to me?

We don't know if being in this research study will help you feel better if found to be sick. But we hope to learn something that will help other people someday such as primary school children's nutrient status, their soil transmitted worms and their dietary patterns.

Do I have other choices?

You can choose not to be in this study

Will anyone know I am in the study?

We won't tell anyone you took part in this study. When we are done with the study, we will write a report about what we found out. We won't use your name in the report.

What happens if I get hurt?

Your parents have been given some personnel's contact information in case they are not happy or you get hurt. Before you say yes to be in this study; be sure to ask the doctor or the main person conducting the study to tell you more about anything that you don't understand.

What if I do not want to do this?

You don't have to be in this study. It's up to you. If you say yes now, but you change your mind later, that's okay too. All you have to do is tell us.

If you want to be in this study, please sign or print your name.

□□ Yes, I will be in this research study. □ No, I don't want to do this.

____________________________	____________________	_____________
Child's name	signature of the child	Date
____________________________	____________________	_____________
Person obtaining Assent	signature	Date

Appendix 7

Tumalano E E Direlwang Mo Kitsong

Tetla Ya Ngwana

TSHEKATSHEKO YA SEEMO SA DIKOTLA MO BANENG (6 to 13) BA MALWAPA A TEMO YA *MOLAPO* MO TUBU LE SHOROBE, NGAMILAND, BOTSWANA

Mokanoki mogolo: Dr. L. Magole (PhD)

Bakanoki ba bangwe: Galase Ramolefhe (MSN), Nnyepi M. (PhD) le Ama N. O (PhD)

Dinomore tsa Megala: (267) 681 7227; (267) 681 7201

Re batla go go bolelela ka tshekatsheko e re e dirang. Tshekatsheko e botlhokwa fa o batla go itse ka sengwe. Re batla go itse ka seemo sag ago sa dikotla. Re kopa thotloetso ya gago ka go tsenelela tshekatsheko e. Re go tlhopha jaana ka o mongwe wa ba dingwaga tse di thataro go ya bosome le boraro (6 to 13 years) mme e bile o le ngwana wa balemi.

Fa o na le keletso ya go tsenelela tshekatsheko e, re tla kopa gore re go tsee madi le mantle, o arabe dipotso ka mekgwa ya gago ya go ja le go lebelela kgolo ya gago. Re tla dira se ga bedi (NOWember and May) mo tshekatshekong. Ngaka o tla dirisa lemao le le ntsha le le sekono go go tsaya madi mo letsogong. Re batla selekanyo sa leswana le letona le le jang. Se se tla re thusa gore re kgone go bona gore seemo sa gago sa dikotla se ntse jang le gore a o gola sentle. Re tla go fa selwana se o tla se dirisang go re tsenyetsa mantle mo teng, selekanyo sa leswana la tee. Re a go a tlhatlhoba re bona gore a go na le dibokwana mo teng tse di ka go lwatsang. O tla tsena mo ntlwaneng o le nosi.

<u>A go na le se se ka ntiragalelang se se sa siamang?</u>

Re batla go go itsese ka dingwe tse di ka go diragalelang mo tshekatshekong e. Lemao le le dirisiwang go tsaya madi le ka go utlwisa botlhokonyana, la go ntsha letsadi kana la ira gore o ikutlwe o na le sedidi fa go fediwa. Mme re tla go rotloetsa go nna fa fatshe re bo re go fa borotho le seno fela fa o fetsa go fokotsa sedidi se. Re tla dirisa ngaka yo o rutetsweng go tsaya madi mo go wena go fokotsa dikgobalo.

A go na le se se ka ntiragalelang se se siameng?

ga re solofetse gore go tsenelela tshekatsheko e go ka go fodisa fa o itlhelwa o lwala mme re ka ithuta go le gontsi. Dithuto tse di ka solegela bana ba bangwe mosola ka go thusa go tlhaloganya go le gontsi ka seemo sa dikotla mo baneng le mabaka mangwe a a ka baang seemo se mo mosing jaaka mekgwa ya go ja le dibokwana tsa mmu.

<u>A kena le sebaka sa go itlhophela?</u>

Ee o na le tetla ya go itlhophela go tsenelela kana go sa tsenelele tshekatsheko e

<u>A go na le yo o tla itseng fa ke tseneletse tshekatsheko e?</u>

Ga re kake ra bolelela ope fa o tseneletse tshekatsheko e. Fa re khutlisitse tshekatsheko e, re tla kwala mokwalo ka maduo a rona. Itse fa leina la gago le ka se tlhagelele gope.

<u>Go tla diragalang fan ka bolaisega mo tshekatshekong e?</u>

Batsadi bag ago ba filwe mokwalo le dinomore tsa megala tse ba ka ikgolaganyang natso fa go ka diragala gore ba bo ba sa itumedisiwa ke sengwe. Pele o dumela go tsaya karolo, botsa ngaka kana moeteledi pele wa tshekatsheko go go bolelela tsotlhe tse o sa di tlhaloganyeng.

Jaanong ga ke sa batle go tsenelela tshekatsheko?

Ga o pateledîwe go tsenelela tshekatsheko e. Go tswa mo go wena. Fa o ne o dumalane o santse o letlelelwa go hetola mogopolo. Re itsese fa go ntse jalo.

Fa o na le keletso ya go tsenelela tshekatsheko e, tswee tswee gatisa tumalano e ka go kwala leina la gago ka botlalo.

☐ Ee ke tla tsenelela tshekatsheko. ☐ Nnya ga ke batle go tsenelela tshekatsheko.

____________________________	____________________	_____________
Leina la ngwana	monwana wa ngwana	Letsatsi
____________________________	____________________	_____________
Motho yo o tsamaisang tumalano e	Tshaeno	Letsatsi

A re ka tswelela?

Ee______________________________

Nnya______________________________

Fa o sa dumalane tswee tswee re bolelele mabaka a gago

Re a leboga ☺

Appendix 8

Household Food Insecurity Access Scale (English)

			If Yes, how often did this happen?		
1. In the past four weeks, did you worry that your household would not have Enough food?	Yes	No	1 = Rarely (once or twice in the past four weeks)	2 = Sometimes (three to ten times in the past four weeks)	3 = Often (more than ten times in the past four weeks)
2. . In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack	□	□	□	□	□

of resources?					
3. In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	☐	☐	☐	☐	☐
4. n the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	☐	☐	☐	☐	☐
5. In the past four weeks, did you or any household	☐	☐	☐	☐	☐

member have to eat a smaller meal than you felt you needed because there was not enough food? (**smaller servings)**					
6. In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food? (**fewer number of meals/day)**	☐	☐	☐	☐	☐
7. In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	☐	☐	☐	☐	☐

8. In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	☐	☐	☐	☐	☐
9. In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	☐	☐	☐	☐	☐

Food Assistance	**Yes**	**No**
10 Have you received food assistance in the past three months?	☐	☐

Appendix 9

Household Food Insecurity Access Scale (Setswana)

			If Yes, how often did this happen?		
11 Mo dibekeng tse nne tse di fetileng a o kile wa thobaediwa ke gore ba lelwapa la gago ga bana go nna le dijo tse di lekaneng?	Ee	Nnyaa	**Ka sewelo =** ga ngwefela kana ga bedi ka kgwedi	**Nako nngwe =** ga raro go ya ga some ka kgwedi	**Ga ntsi** = go feta ga some ka kgwedi
12 Mo dibekeng tse nne tse di fetileng, a go kile ga diragala gore wena kana mongwe wa ba lelwapa la gago a se ka a kgona go ja dijo tse a neng a eletsa go dija ka lebaka la gore go ne go sena ditsompelo?	☐	☐	☐	☐	☐
13 Mo dibekeng tse nne tse difetileng, a go kile ga diragala gore wena kana mongwe wa ba-lelapa la gago a bo a tshwanelwa ke go ja dijo di le di ngwefela/tse ditshwanang ka gore go ne go sena ditsompelo?	☐	☐	☐	☐	☐

14	Mo dibekeng tse nne tse di fetileng, a go kile ga diragala gore wena kana mongwe wa ba lelwapa la gago a patelesege go ja dijo tse a neng a sa batle go dijo ka gore go ne go sena dijo dipe kana ditsompelo tsa go di reka.	□	□	□	□	□
15	Mo dibekeng tse nne tse di fetileng, a go kile ga diragala gore wena kana mongwe wa ba lelwapa la gago a je dijo tse tsa selekanyo se sennye go na le jaaka a ne a eleditse ka gore go ne go sena dijo tse di lekaneng? (**smaller servings)**	□	□	□	□	□
16	Mo dibekeng tse nne tse di fetileng, a go kile ga diragala gore lonne le makgetho a go jela ko tlase go na le ka fa lo ne lo eletsa ka teng ka gore ka letsatsi go ne go sena dijo kana ditsompelo (**fewer number of meals/day)**	□	□	□	□	□

17 Mo dibekeng tse nne tse di fetileng, go kile ga diragala gore go bo go ne go sena dijo dipe mo lapeng kagore go ne go sena ditsompelo tsa go reka dijo?	☐	☐	☐	☐	☐
18 Mo dibekeng tse nne tse di fetileng, a go kile ga diragala gore wena kana mongwe wa ba lelwapa la gago a robale a tshwerwe ke tlala ka gore go ne go sena dijo tse di lekaneng?	☐	☐	☐	☐	☐
19 Mo dibekeng tse nne tse di fetileng, a go kile ga diragala gore wena kana mongwe wa ba lelwapa la gago a tlhole letsatsi lotlhe le bosigo botlhe a sa ja sepe ka gore go ne go sena dijo tse di lekaneng	☐	☐	☐	☐	☐

Food Assistance	**Ee**	**Nnyaa**
20 A o kile wa thusiwa ka dijo ka na wa phakisiwa dijo kgwedi le kgwedi mo kgweding tse tharo tse di fiteleng?	☐	☐
21 A mo sebakeng sa gompieno a o bona thuso ya dijo ee itumedisang?	☐	☐

22 Fa ele gore o bona thuso ya dijo, o e bona kae/ o fiwa ke bafe? a. Dijo ke di fiwa ke mokgatho mongwe (NGO) kgwedi nngwe le nngwe (monthly)	□	□
b. Dijo ke di fiwa ke lekalana lengwe la puso kgwedi le kgwedi (monthly)	□	□
c. Ke fiwa dijo ke bangwe (tlhalosa gore ke bafe?____________________) ____________________	□	□

Appendix 10

Main Questionnaire (English)

PhD NUTRITION PROJECT SURVEY INSTRUMENT

CHILD NAME AND CODE: ____

Date of interview:

____

Name of interviewer:

____

Name of respondent:

____

Name of village:

____

Name of ward:

____

Nutritional Status of Children (6 to 13 years) in Farming Areas

Starting time:

____

Finishing time:

____

Hello, my name is ____. I am a student under the Botswana Eco-Health Project at the Okavango Research Institute/University of Botswana, Maun Campus. I am conducting a study on the nutritional status of children (6 to 13 years) in this village. Please note that the questionnaire should be answered by the caregiver together with the child.

SECTION A: CAREGIVER INFORMATION

CARETAKER'S RELATION TO CHILD

____

If caretaker is not the mother, write is his/her gender here

____

1. MARITAL STATUS

   01 Never married/single

   02 Married

03 Divorced/separated

04 Widowed

05 Living together

2. HIGHEST LEVEL OF EDUCATION ATTAINED

____

3. CAREGIVER OCCUPATION

____

Information on the child’s parents

4. Is this Child’s biological mother alive?

   01 Yes

   02 No

5. How old is the mother of this child (use ID/Omang (dd/mm/yyyya))?

____

6. Is this child’s biological father alive?

   01 Yes

   02 No

7. How old is the biological father of this child? (Use ID/Omang (dd/mm/yyyy))

____

8. What is the marital status of the child's biological mother?

    01 Never married/single

    02 Married

    03 Divorced/separated

    04 Widowed

    05 Living together

9. What is the marital status of the child's biological father?

    01 Never married/single

    02 Married

    03 Divorced/separated

    04 Widowed

    05 Living together

10. Do the child's biological parents live in the same household?

    01 Yes

    02 No

11. Is the child staying with both biological parents?

12. Highest education level achieved by the child's Mother

____

____

____

13. Is the household income enough to get food for the child for the rest of the month?

____

____

____

SECTION B CHILD BACKGROUND AND ANTHROPOMETRICS

1. Child name:____ Sex: F___ M____

2. Birth date (dd/mm/yyyy) [Refer to clinic card or birth certificate]:

____

3. Where was this child born?

a. Health facility at (name of place)

____

b. Home (state village)

____

4. Birth order amongst siblings:______________________ Birth weight in kg:________

5. Current weight in kg:_____________________ Current Height/length in cm:_______

6. If attending school state the grade/standard you are in:

   ____

7. BMI

   (kg/m^2)____

8. MUAC

   (cm)____

9. Number of people living in the

   household:____

10. Number of children 13 years and below in the

   household:____

11. Number of people child sleeps with in the sleeping room:

____

____

SECTION C: HOUSEHOLD FOOD SECURITY

1. Where did you plant this season?
    a. *Molapo* farm
    b. Rain-fed farm
    c. both
2. Were you able to plough and plant as usual for the following years
    a. 2010 Yes____________________________ No___________________
        i. If not state the reason why

        ____

        ____

        ____

    b. 2011 Yes____________________________ No___________________
        i. If not state the reason why

        ____

        ____

        ____

c. 2012 Yes________________________ No_______________________

i. If not state the reason why

____

____

____

3. What type of crops did your harvest in the following years?

a. The year of 2010

____

____

____

b. The year of 2011

____

____

____

c. The year of 2012

____

____

____

d. The year of 2013

____

____

____

4. Did the food finish or last until next planting season?

____

____

____

5. If the food finished how did you help yourself?

____

____

____

6. Is the child receiving any nutritional supplement (multivitamin, special mixes with concentrated vitamins and minerals etc)?
    a. Yes
    b. No

7. If yes, how much of it is the child taking and please mention the brand of the product

____

____

____

8. Is this supplement prescribed at the clinic?
    a. Yes
    b. No

9. If the child is taking a supplement and it is not prescribed at the clinic, who recommended it and why?

    ____

    ____

    ____

SECTION D: SOIL TRANSMITTED HELMINTH INFESTATIONS AND HEALTH

1. Has the child been ill in the past month?
    a. Yes
    b. No

2. If yes what action taken?
    a. Taken to a health facility
    b. Taken to traditional medicine practitioner
    c. Other

    (specify)____

3. **Parasitic infestation symptoms** Did you experience the following symptoms in the last month? Tick (√)

SYMPTOMS	YES	NO
Abdominal pain		
Bloating and or intestinal gas		
constipation		
Loss of appetite		
Constant itching especially in the anal area		
Visible Worms in the stools		
Blood in the stools		
Sleep disturbance		
Wt loss		
Diarrhoea (passing loose stools 3 or more times within a 24 hour period)		

a. Watery diarrhoea b. Blood diarrhoea		
Skin disorders (rashes, hives, eczema, psoriasis, boils and or acne)		
Frequent bouts of ear, nose, or throat infections		
fever		
Nausea		
Dry cough		
vomiting		
Weakness and or feeling tired at all times		
Joint and or muscle pain		
Malaria		
Bilhazia		
Other		

4. Do you suspect your child may have worms in their stomach?
    a. Yes
    b. No

5. What are the symptoms leading to this suspicion?

____

____

____

6. What do you think is the cause of these worm infestations/infections if present?

____

____

____

7. Has the child been diagnosed with worm infections in the past 4 weeks?
    a. Yes
    b. No

8. Has the child been diagnosed with worm infections in the past year? If so how often (information can be retrieved from clinic cards)
    a. Yes
    b. No

9. What type of toilet do you use?
    a. Pit latrine
    b. Flush toilet
    c. No toilet but use our neighbors
    d. Use the bush

10. Does the child wash hands every time after using the toilet and or before eating or handling food?
    a. Yes
    b. No

11. Do you own pets?
    a. Yes
    b. No

12. If so please name them?

____

____

____

Hygiene and Sanitation

13. What kind of a toilet facility does the family use?
    a. Flush toilet 1Always 2 Sometimes 3. Never

b. Pit latrine 1Always 2 Sometimes 3. Never

c. Bush 1Always 2 Sometimes 3. Never

14. Do you wash your hands after going to the toilet?

a. Yes

b. No

15. Do you wash your hands after using the toilet?

1. Always 2. Sometimes 3. Never

16. Do you wash your hands before you eat?

1. Always 2. Sometimes 3. Never

17. Do you use clean water and soap to wash your hands?

a. Yes

b. No

c. Other____

18. How do you wash your hands?

a. Wet hands with warm clean water, put soap, rub hands and then rinse with more clean water and wipe with clean towel

b. I rinse my hands with water only

c. Other____

19. When I play outside I put my shoes on.

    1. Always 2. Sometimes 3. Never

20. Where do you store food at home?

    ____

    ____

    ____

21. Please explain how you normally cOver food and or water at home (does the lid fit, use mesh? etc)

    ____

    ____

    ____

22. Do you ever eat raw food (fruits and vegetables etc)?

    a. Yes

    b. No

23. Do you wash raw foods before you consume them?

    a. Yes

    b. No

24. Where do you fetch drinking water from?

____

____

____

25. Who fetches the water?

____

____

____

26. How do you treat water to make it safe and how often do you do this?

____

____

____

27. How often do you swim in the river/stream/lake etc?

28. Is the child involved in tending to *molapo* farms?

    a. Yes

    b. No

29. If yes what duties is the child involved in?

____

____

____

30. Do you ever eat soil?

   a. Yes   i) always   ii)sometimes   iii) Never

   b. No

31. If you eat soil why do you eat it?

____

____

____

32. When did you start eating soil?

____

____

____

Child observation (Look at the child and write **any** observations about the child)

____

____

____

Appendix 11

Household Dietary Diversity (English)

24 HR FOOD RECALL

IDENTIFICATION		
QO1	CHILD NAME /CODE	________________________
Q02	RESPONDENT	________________________
Q03	LOCALITY NAME	________________________
Q04	CHILD DOB & SEX	

Number of day:________________ Date of visit :___________ (dd/mm/yyyy)

School attendant? Yes_____ No_____ If yes what standard is the child in?_____

Weight_______________________________ kg Height _________________________ cm

(To be completed for those chosen to participate in the subsample only!)

Please include the food groups consumed by household members in the home, or prepared in the home for consumption by household members outside the home (e.g., at lunchtime in the fields). Please do not include foods consumed outside the home that were not prepared in the home.

Question number	**Food Group**	**Examples**	**YES=1 NO =0**
1	Carbohydrates or starchy foods?	bread, rice noodles, biscuits, cookies, or any other foods made from millet, sorghum, maize, rice,	

		Wheat, or [INSERT ANY OTHER LOCALLY AVAILABLE GRAIN]?	
2	Vitamin A rich Vegetables (orange or yellow inside)?	Any pumpkin, carrots, squash, or sweet potatoes that are yellow or orange inside	
3	White potatoes or any other foods made from roots or tubers?	Any white potatoes, white yams, manioc, cassava	
4	Any dark, green, leafy vegetables?	cassava leaves, bean leaves, kale, spinach, pepper leaves, taro leaves, amaranth leaves, pumpkin leaves, rape, and other leafy vegetables commonly consumed in the community eg (Thepe, rothwe and chomolia)	
5	Any other vegetables?	cabbage	
6	Vitamin A rich fruits (orange or yellow fleshed)?	Mangoes, peaches, pears and locally occurring vitamin A rich fruits such as moretologa, mompudu, mmilo, mogorogorwana, mogwagwa and motoroko	
7	Any other fruits?	Oranges, apples, mulberry/berries, bananas	
8	Organ meats (iron rich)?	liver, kidney, heart	
9	Flesh Meats?	Any beef, pork, lamb, goat, rabbit wild game, chicken, duck, or other birds	

10	Eggs?	All types	
11	Fish?	All types	
12	Legumes and or food made from legumes?	beans, peas, or lentils,Peanuts, peanut butter, nuts etc	
13	Milk and milk products?	Milk, cheese, yogurt, sour milk, sour cream etc	
14	Foods made from oil, fat or butter?	Fat, oil, butter, cooking oil, mayonnaise salad dressings, cheese spreads	
15	Food made from sugar?	Sugar, honey, cold drinks, orange squash, candy	
16	Spices, condiments, beverages and other foods not mentioned?	Salt, coffee, tea, spices, alcohol etc	
			YES=1 **NO=0**
You		Have you eaten outside the home yesterday?	
Any family member		Has anyone in the family eaten outside the home yesterday?	

Appendix 12

Household Food Insecurity Access Scale Score Tabulation Plan

Source: Coates J, Swindale A and Bilinsky P (2007). Household food insecurity access scale (HFIAS) for measurement of food access: Indicator Guide. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development

The HFIAS score is a continuous measure of the degree of food insecurity (access) in the household in the past four weeks (30 days).

a. First, a HFIAS score variable is calculated for each household by summing the codes for each frequency-of-occurrence question. Before summing the frequency-of-occurrence codes, the data analyst should code frequency-of-occurrence as 0 for all cases where the answer to the corresponding occurrence question was “no” (i.e., if Q1=0 then Q1a=0, if Q2=0 then Q2a =0, etc.).
b. The maximum score for a household is 27 (the household response to all nine frequency-of-occurrence questions was “often”, coded with response code of 3); the minimum score is 0 (the household responded “no” to all occurrence questions, frequency-of-occurrence questions were skipped by the interviewer, and subsequently coded as 0 by the data analyst.)

c. The higher the score, the more food insecurity (access) the household experienced. The lower the score, the less food insecurity (access) a household experienced.

HFIAS Score

a. (0-27): Sum of the frequency-of-occurrence during the past four weeks for the 9 food insecurity-related conditions
b. Sum frequency-of-occurrence question response code (Q1a + Q2a + Q3a + Q4a + Q5a + Q6a + Q7a + Q8a + Q9a)

Appendix 13

Household Food Insecurity Access Category Tabulation Plan

Source: Source: Coates J, Swindale A and Bilinsky P (2007). Household food insecurity access scale (HFIAS) for measurement of food access: Indicator Guide. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development

c. First, a HFIA category variable is calculated for each household by assigning a code for the food insecurity (access) category in which it falls.
d. The data analyst should have coded frequency-of-occurrence as 0 for all cases where the answer to the corresponding occurrence question was "no" (i.e., if Q1=0 then Q1a=0, if Q2=0 then Q2a =0, etc.) prior to assigning the food insecurity (access) category codes.
e. The four food security categories should be created sequentially, in the same order as shown below, to ensure that households are classified according to their most severe response.

HFIA category

a. Calculate the Household Food Insecurity Access category for each household. 1 = Food Secure, 2=Mildly Food Insecure Access, 3=Moderately Food Insecure Access, 4=Severely Food Insecure Access
b. HFIA category = 1 if [(Q1a=0 or Q1a=1) and Q2=0 and Q3=0 and Q4=0 and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]

c. HFIA category = 2 if [(Q1a=2 or Q1a=3 or Q2a=1 or Q2a=2 or Q2a=3 or Q3a=1 or Q4a=1) and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]

d. HFIA category = 3 if [(Q3a=2 or Q3a=3 or Q4a=2 or Q4a=3 or Q5a=1 or Q5a=2 or Q6a=1 or Q6a=2) and Q7=0 and Q8=0 and Q9=0]

e. HFIA category = 4 if [Q5a=3 or Q6a=3 or Q7a=1 or Q7a=2 or Q7a=3 or Q8a=1 or Q8a=2 or Q8a=3 or Q9a=1 or Q9a=2 or Q9a=3]

Appendix 14

HDDS Indicator Tabulation Plan

a. The HDDS variable is calculated from consumption of 12 food groups. If food group is consumed, a value of 1 is given for that particular food group and if not then a 0.
b. Range of HDDS can be from 1-12
c. The higher the score the diverse the diet

Source: Swindale A and Bilinsky P. (2006). Household Dietary Diversity Score (HDDS) for measurement of household food access: indicator guide (Version 2). Washington, D.C.: FHI 360/FANTA

Appendix 15

Research Permit

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MINISTRY OF HEALTH
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GABORONE

REPUBLIC OF BOTSWANA

REFERENCE No: PPME 13/18/1 Vol VII (179) **31 October 2011**

Health Research and Development Division

Notification of IRB Review: **New Application**

Prof. M.J. Chimbari
Private Bag 285
Maun

Dear Prof. Chimbari

PERMIT: ECO HEALTH APPROACH TO UNDERSTAND FLOOD-RECESSION (MOLAPO) FARMING IN THE CONTEXT OF HYDRO-CLIMATE VARIABILITY AND HYDRO-CLIMATE CHANGE IN THE OKAVANGO DELTA, BOTSWANA.

Your application for a research permit for the above stated research protocol refers. We note that your proposal has been reviewed and approved by the University of Botswana Office of Research and Development and the Okavango Research Institute Ethics Committees.

Permission is therefore granted to conduct the above mentioned study. This approval is valid for a period of 1 year effective 31 October 2011.

The permit includes the following sub studies:

1. Malaria transmission dynamics in Tubu village, Ngamiland District in Northern Botswana.
2. Schistosomiasis transmission in Tubu, Shorobe and Xobe Villages in Ngamiland District
3. Nutritional Status of Children in Tubu, Xobe, Shorobe molapo farming households, Ngamiland, Botswana.

This permit does not however give you authority to collect data from the selected sites without prior approval from the management. Consent from the identified individuals should be obtained at all times.

The research should be conducted as outlined in the approved proposal. Any changes to the approved proposal must be submitted to the Health Research and Development Division in the Ministry of Health for consideration and approval.

Furthermore, you are requested to submit at least one hard copy and an electronic copy of the report to the Health Research and Development Division, Ministry of Health within 3 months of completion of the study. Copies should also be submitted to all other relevant authorities.

If you have any questions please do not hesitate to contact Mr. P. Khulumani at pkhulumani@gov.bw, Tel +267-3914467 or Mr. Lemphi Moremi at lmoremi@gov.bw or Tel +267-3632464.

Thank you for your cooperation and your commitment to the protection of human subjects in research.

Yours sincerely

P. Khulumani
For Permanent Secretary

MINISTRY OF HEALTH
DEPT. OF POLICY PLANNING, MONITORING AND EVALUATION
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